

**ORIGINAL CONTAINS
COLOR ILLUSTRATIONS**

ENGINEERING EVALUATION OF 24-CHANNEL MULTISPECTRAL SCANNER

INFRARED AND OPTICS DIVISION
WILLOW RUN LABORATORIES
INSTITUTE OF SCIENCE AND TECHNOLOGY
THE UNIVERSITY OF MICHIGAN



NASA Manned Spacecraft Center
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ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

(NASA-CR-134179) · ENGINEERING EVALUATION
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Willow Run Laboratories

INFRARED AND OPTICS DIVISION

INSTITUTE OF SCIENCE AND TECHNOLOGY
THE UNIVERSITY OF MICHIGAN
POST OFFICE BOX 618
ANN ARBOR, MICHIGAN 48107
Telephone 313-483-0500

National Aeronautics and Space Administration
Manned Spacecraft Center
Information Systems Division
Houston, Texas 77058

Attention: Mr. James Kessel/EB8

Subject: Engineering Evaluation of 24-Channel Multispectral Scanner

An engineering evaluation of the 24 channel scanner system performance based on analysis of flights on 2 June and 4 June 1972 and on ground test data taken during May 1972. The report also includes recommendations on improvement and modifications to enhance system operation and performance. In general the system performed better than ever before and NASA is to be commended on their rework effort.

Key points in the report are as follows:

1. All channels were operating during the 2 and 4 June 1972 flights.
2. The maximum misregistration between channels was about 1 resolution element (reselem) which was caused by differing detector amplifier responses. Even though good radiance measurement is not obtained until after 3 reselem, the maximum misregistration should probably be less than .5 reselems. In addition a number of channels exhibited a long time to get within a few percent of final value. It is recommended that electronic compensation be added to tailor the response to reduce the misregistration to less than .5 reselems and to reduce the settling time to within 2 reselems after the 50 percent response for less than 5 percent error from the final value.
3. The analog portion of the video channels exhibits considerable drift in gain and offset. It is recommended that these circuits be improved to maintain the signal from the calibration sources (excluding detector noise) to within ± 2 percent of the dynamic range from the set value. In addition it is common for channel 16 video signal to have considerable offset from the other thermal channels. It is recommended that this channel have an offset adjustment range which allows the signal from calibration source 5 to be set anywhere in the dynamic range of the system.

4. The design of the MSDS system inside the aircraft to some extent invites errors on the part of the operators. In particular the two separate sets of controls for ΔT , one set to actually change ΔT and the other set just to arrange for ΔT to be recorded properly in the housekeeping data on the flight tape, invites the operator to perform adjustments in ΔT as requested but to neglect to adjust the housekeeping controls to allow the value to be recorded properly, as was found to happen during run 14 on 4 June. The scale and offset selector switches for each of the channels are small and are difficult to read and to operate, consequently throughout the 2 June edits we received channel 3 appears set at a scale of 2X (rather than 1X), while channel 6 appears set at 2X scale (rather than 1X) for runs through run 7, and channel 2 appears set at .25X scale (rather than 1X) for the A/D and I/H tests which preceded the other runs on that day. It is recommended that these operator controls be redesigned and laid out so as to minimize these errors.

5. The scan motor operation is marginal when operated in a sustained basis at low altitude on a hot day. If this has not been fixed it is recommended that it be fixed.


6. The housekeeping and control panel indication of blackbody temperatures didn't agree by over 1°C. It is recommended that this be corrected.

7. The process of obtaining camera film, scanner color film and some other supporting data was too long. The delay in obtaining the color scanner film was due to the very low throughput of the data analysis station while the delay in obtaining the camera film is a paperwork problem. It is recommended that this be improved.

8. I fault myself in not specifying in the mission plan the exact start and stop point for the mission manager to conduct a run. It is important for the runs to start and stop at a preset location to aid in data recovery from the flight tapes.

This report does not address calibration accuracy. This is expected to be covered in a later report; however, lamp current variations obtained during this analysis indicate the specified accuracy is not being obtained.

If there are questions regarding this report, please contact Leo M. Larsen at 313-483-0500, extension 444.



LEO M. LARSEN
Principal Investigator

Flight Plan and Test Site

In early June of 1972 two flights of the MSDS were conducted over the Willow Run Airport to gather data for evaluation of the performance of the total system. Only one flight had been requested, but an additional flight was suggested by NASA. Data gathering concentrated primarily on an area at the north end of a ramp at the airport where a painted resolution chart existed and where gray and colored panels with known reflectance characteristics had been placed. Figures 1.1 and 1.2 are prints from RC-8 photographs taken from the plane during run 12 of each flight. The black stripes on the ramp are tar paper strips which were laid out to test for moire patterns in the digitized data. Figure 1.3 is another print from an RC-8 photograph, taken during run 2 on 4 June, showing the total basic flight line, which ran north to south along the ramp and continued in a straight line to cross Belleville Lake, to the south of the airport.

The flight plan was identical for both flights, calling for runs at a variety of altitudes (and V/H's), with various gain and offset settings for the channels, and with one run flying south to north rather than north to south. This flight plan is shown in Figure 1.4. Scan motor heating problems prevented the 2 June flight from being continued past run 17.

The weather for the two flights, uniquely different from one day to the other, provided data of particular interest from both flights. On 2 June there was a uniform overcast such that the shadows of objects on the ground were barely discernible, and then only occasionally, while on 4 June the weather was virtually crystal clear with only a few very small clouds appearing in the afternoon. On this latter day the test area on the ramp was never in cloud shadow. This latter day was also the only day of the two which fulfilled the desired weather objectives for the flight initially requested, and is the source for the bulk of the data presented in this report.

Figures 1.5 and 1.6 show a scale diagram of the layout of the test area on the ramp for each day. The resolution chart, as drawn, is inaccurate in the number and exact placement of the smallest bars of the chart; actually, each sequence in the chart takes up the length shown, but each has three more bars than indicated, the last of which is a 6" to 12" sliver, generally not discernible from the air. Note the differences in placement of the charcoal fire, tar paper strips, and olive drab (O.D.), black, and aluminum panels on the two days. Note also that Figures 1.5 and 1.6 are the only diagrams in this report which follow the normal convention of having north at the top of the page. All other photographs and diagrams have south at the top of the page since the flight line usually ran north to south.

PERFORMANCE OF MSDS AS OF 2 AND 4 JUNE 1972

FOREWORD

This report describes the system performance evaluation of the 24 channel multispectral scanner based on the data generated on 2 and 4 June 1972.

The evaluation described herein was performed under NASA Contract NAS 9-9784, modification number 11S, exhibit C.

The work was performed under the direction of R. R. Legault, Head of the Infrared and Optics Division and Associate Director of Willow Run Laboratories. The Principal Investigator of this task is L. M. Larsen. This report was written by P. F. Lambeck.

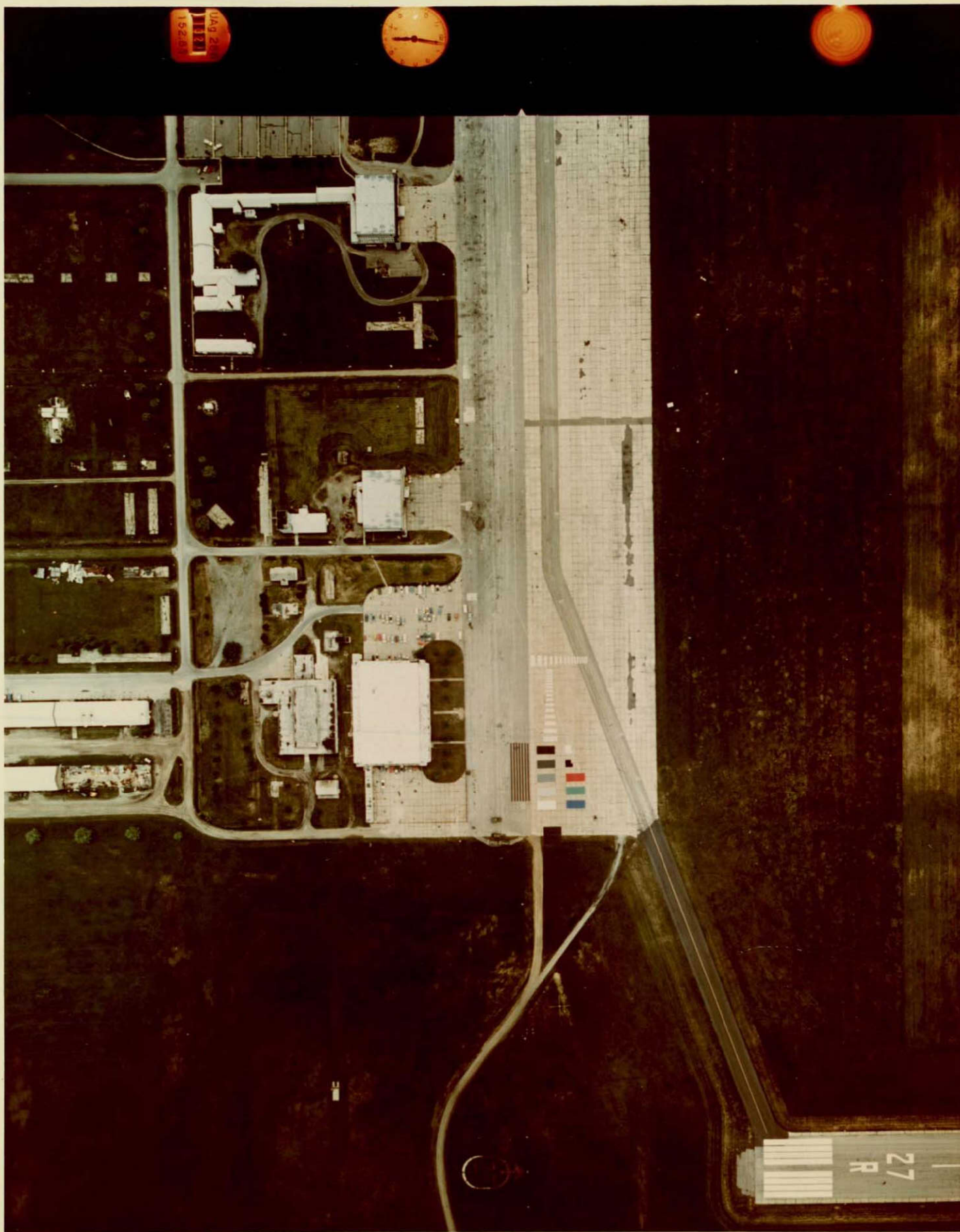


Figure 1.1
1.7K ft. of targets
6/2/72 (overcast)

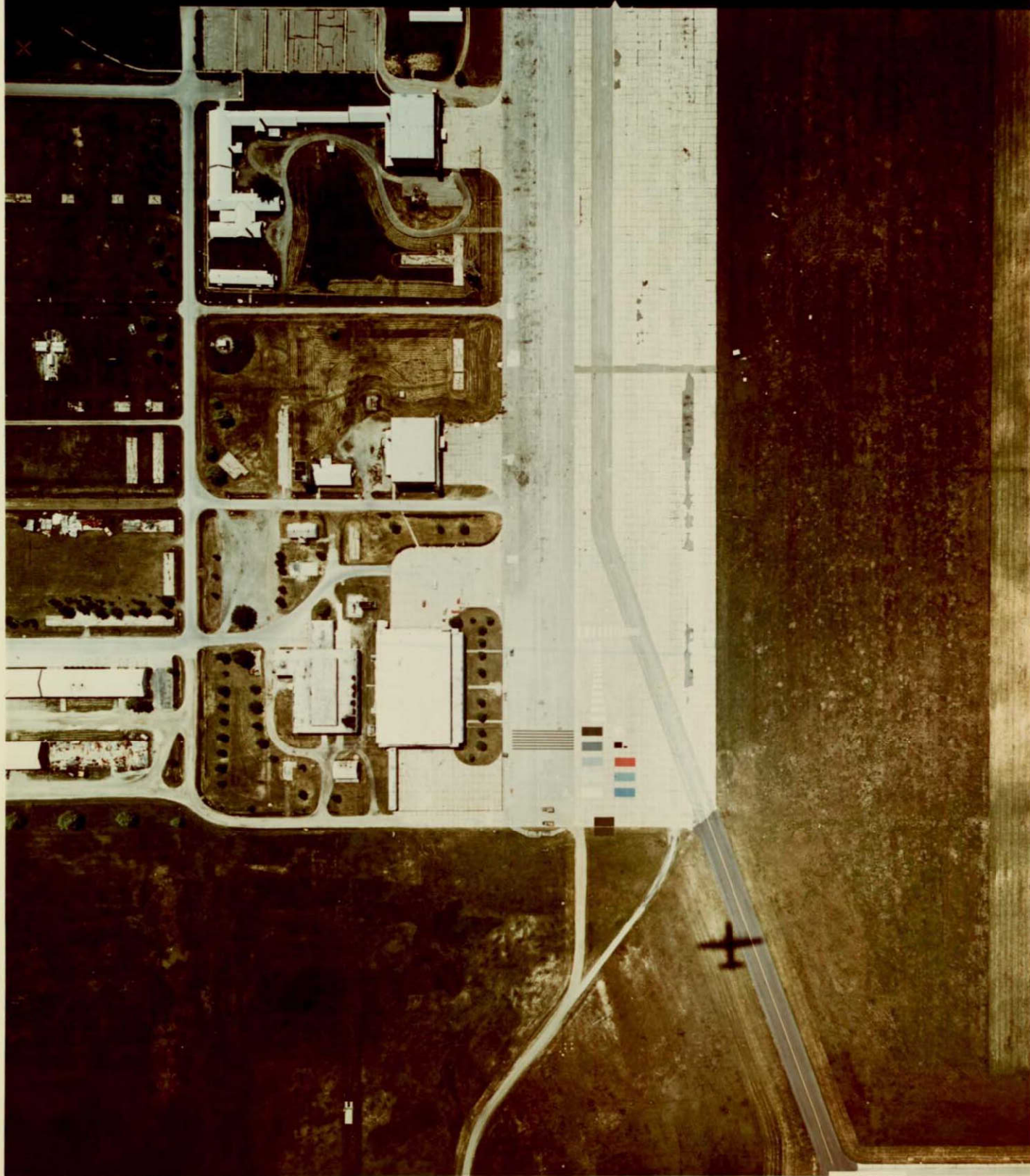


Figure 1.2
1.7K ft. of targets
6/4/72 (clear)



Figure 1.3
14.7K ft. of flight
area 6/4/72

Flight 2 Mission (MSDS Settings for a Bright Sunny Day)

Flight Line Run No.	Alt. Above Grd. (K ft.)	Grd. Speed (knots)	Grd. Track Heading (deg.)	V/H	Ch. 1-13, 23 & 24				Ch. 14-22				Film Rec. (ch.)	Comments	
					Cal. Source	Filter Select	Scale	Offset	Cal. Source	Low Temp. Set (°C)	ΔT (°C)	Scale			Offset
2-1	1.7	160	180°	.16	2	1	1X	1	1	*	40	1X	1	18	
2-2	14.7	200	180°	.023	2	1	1X	1	1	*	40	1X	1	20	
2-3	10.0	160	180°	.027	2	1	1X	1	1	*	40	1X	1	2	
2-4	10.0	160	180°	.027	2	1	.25X	1	1	*	40	.25X	1	15	
2-5	6.7	160	180°	.04	2	1	1X	1	1	*	40	1X	1	4	
2-6	4.5	160	180°	.06	2	1	1X	1	1	*	40	1X	1	17	
2-7	3.4	160	180°	.08	2	1	1X	1	1	*	40	1X	1	14	
2-8	3.4	160	180°	.08	2	1	.25X	1	1	*	40	.25X	1	22	
2-9	3.4	270	180°	.135	2	1	1X	1	1	*	40	1X	1	1	(fast)
2-10	2.7	160	180°	.10	2	1	1X	1	1	*	40	1X	1	10	
2-11	2.3	160	180°	.12	2	1	1X	1	1	*	40	1X	1	21	
2-12	1.7	160	180°	.16	2	1	1X	1	1	*	40	1X	1	3	
2-13	1.7	160	180°	.16	2	1	.25X	1	1	*	40	.25X	1	23	
2-14	1.7	160	180°	.16	2	8	1X	1	1	*	20	1X	1	5	
2-15	1.7	160	180°	.16	2	1	2X	3	1	*	40	2X	3	19	
2-16	1.7	160	180°	.16	1	1	1X	1	1	*	40	1X	1	12	(sun)
2-17	1.7	160	180°	.16	1	1	.25X	1	1	*	40	.25X	1	9	(sun)
2-18	1.5	160	180°	.18	2	1	1X	1	1	*	40	1X	1	8	
2-19	.5	160	180°	.18	2	1	1X	1	1	*	40	1X	1	6	
2-20	1.7	160	180°	.16	2	1	1X	1	1	*	40	1X	1	13	(roll)
2-21	1.7	160	180°	.16	2	1	1X	1	1	*	40	1X	1	7	(pitch)
2-22	1.7	160	180°	.16	2	1	1X	1	1	*	40	1X	1	2	(RFI)
2-23	1.7	160	0°	.16	2	1	1X	1	1	*	40	1X	1	11	(north)
2-24	1.7	160	180°	.16	2	1	1X	1	1	*	40	1X	1	24	
1-1	1.7	160	270°	.16	2	1	1X	1	1	*	40	1X	1	19	(Rolite)
*5°C below Belleville Lake temp. at start of test (not changed)															

*5°C below Belleville Lake temp. at start of test (not changed)

Screwdriver Adjustment Prior to Flight:

Voltages					Voltages					Voltages				
		Level		Cal. S.			Level		Cal. S.			Level		Cal. S.
Ch.		1	2	1 2	Ch.		1	2	1 2	Ch.		1	2	1 2
1	.5	.5	.81	1.0	9	.5	.5	.78	2.0	15	1.0	1.0	4.0	4.0
2	.5	.5	.79	1.0	10	.5	.5	.77	2.5	16	2.5	2.5	4.5	4.5
3	.5	.5	.83	1.1	11	.5	.5	.82	3.5	17	.5	.5	4.5	4.5
4	.5	.5	.85	1.3	12	.5	.5	.80	3.5	18	.5	.5	4.5	4.5
5	.5	.5	.74	1.2	13	.5	.5	.85	4.0	19	.5	.5	4.5	4.5
6	.5	.5	.68	1.1	14	.5	.5	4.5	4.5	20	.5	.5	4.5	4.5
7	.5	.5	.77	1.7	23	.5	.5	.66	4.5	21	.5	.5	4.5	4.5
8	.5	.5	.74	1.7	24	.5	.5	.74	2.5	22	.5	.5	4.5	4.5

Figure 1.4
Flight Plan for 6/2/72 & 6/4/72
(as specified just prior to
flight)

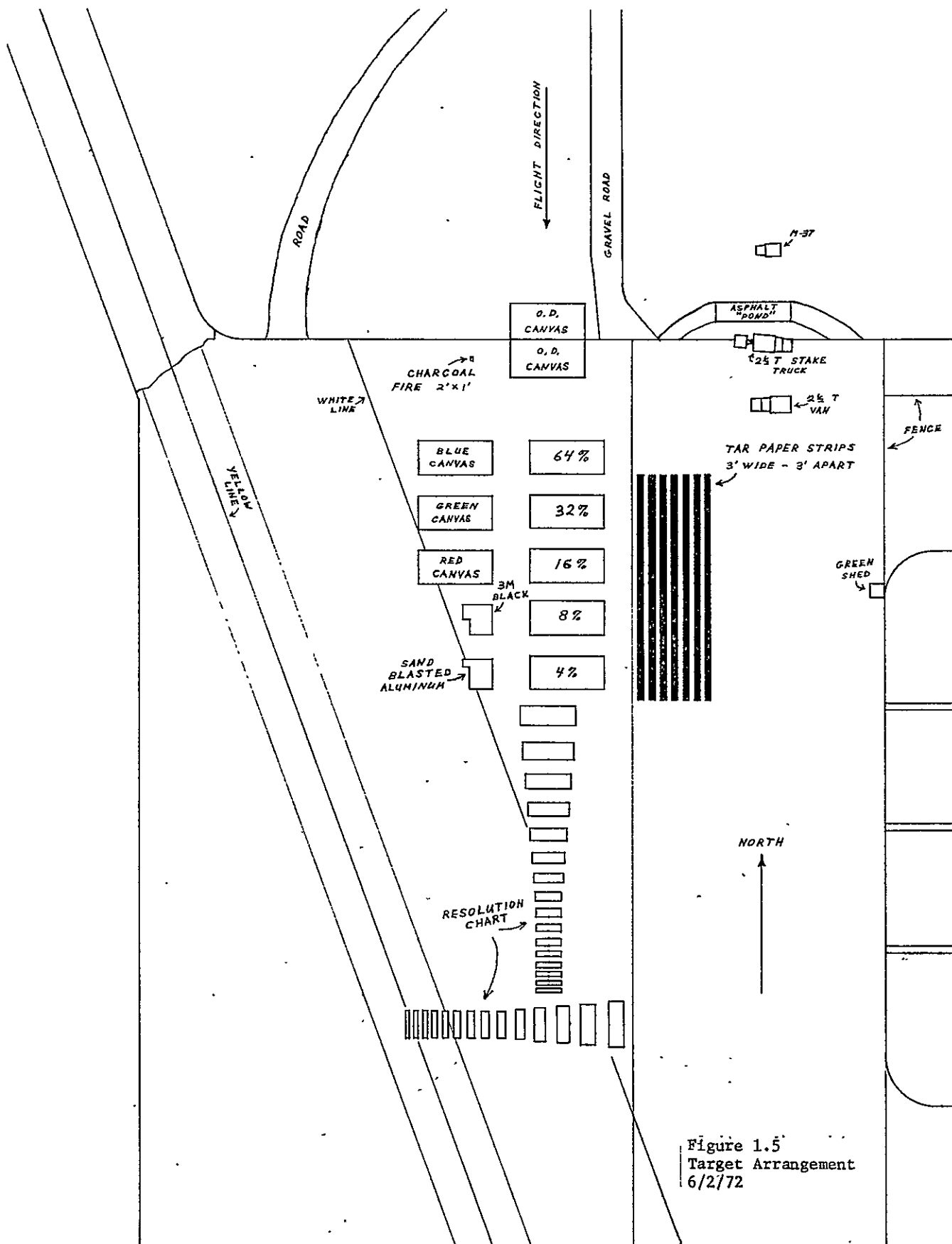
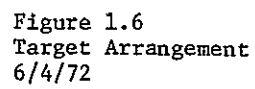


Figure 1.5
Target Arrangement
6/2/72



Time Response and Channel Registration

The response in each channel, scanning across the boundary between the concrete of the ramp and the gray canvas of either the 4 percent or the 32 percent gray panels has been compared to the corresponding response in channel 10 at different V/H's. At a V/H of .18, registration errors between channels of more than one resolution element were not unusual, with thermal channels generally leading channel 10 by 1/2 resolution element while the visible channels generally lagged channel 10 by the same amount. Specifications call for registration between channels to be good to within 1/10 resolution element; however, this is probably too tight to be practical, and registration within plus or minus 1/2 resolution element is probably tolerable. A few channels had an initial fast rise time followed by a second slow rise time. A more detailed discussion follows; at a V/H of .18 - all delays measured relative to channel 10 at 50 percent of total response:

Channels 1 and 2 had good response, anticipating channel 10 by .2 resolution elements (see Figure 2.1).

Channel 3 had overshoots, a strange tendency to be clipped at an intermediate level within the dynamic range of the system, was unusually noisy during run 19 (4 June), and was delayed in response relative to channel 10 by .9 resolution elements (see Figure 2.2 and discussion later in report).

Channel 4 was delayed in response by 1 resolution element and showed a slight slow 2nd exponential response (see Figure 2.3).

Channels 5 through 9 were all delayed in response by about 1/2 resolution element and all showed a slight slow 2nd exponential response, especially in channel 6 (see Figures 2.4 and 2.5).

Channels 10 and 11 had good response with channel 11 showing a very strong bias in favor of odd digital levels rather than even ones.

Channel 12, though noisy, had good response, delayed by only .1 resolution elements, but marred slightly by the presence of a low frequency noise component (see Figure 2.6).

Channel 13 had a noticeable 2nd slow exponential response, but was delayed by only .2 resolution elements (see Figure 2.7).

Channel 14 was erratic, anticipating channel 10 in response by 1 resolution element (see Figure 2.8).

Channel 15 had a very noticeable slow 2nd exponential response and was delayed by .3 resolution elements (see Figure 2.9).

Channels 17 through 20 all anticipated channel 10 in response by about 1/2 resolution element (see Figure 2.10).

Channel 21 had a noticeable slow 2nd exponential response and was delayed by .4 resolution elements (see Figure 2.11).

Channel 22 was delayed in response by more than 2 resolution elements, possibly due to inadequate cooling (see Figure 2.12).

Channels 23 and 24 had good response with channel 23 anticipating in response by .3 resolution elements and channel 24 lagging in response by the same amount.

At a V/H of .08, the misregistration of the channels was generally reduced (in terms of resolution elements) by about half (see Figures 2.13-2.24). Note the presence of the overshoot in channel 3 (Figure 2.14).

As requested, a ground test was run at Hobby Airport, 25 May, scanning across a knife edge. Unfortunately, for much of the data at the high V/H (.18), the knife edge was reversed from the orientation which had been requested, making this data only marginally useful. In general the misregistration of the channels during this test was about the same as during the flight. Some anomalies were noteworthy, however:

Figure 2.25 shows the knife edge properly oriented and indicates a small but noticeable slow 2nd exponential in the response of channels 2 and 9.

Figures 2.26 and 2.27 show the knife edge improperly oriented, but illustrate a peculiarity in the response of channels 4 and 5.

Figure 2.28 shows a small overshoot in channel 11 while Figure 2.29 shows the same overshoot masked by a slow 2nd exponential response in channel 13. Channels 9 through 15 all showed some tendency toward having this small overshoot.

NSS158-72-C, F3 L2 R19 (CLEAR) 0.5K, PANELS, ETC, ON RAMP 18/15/72)

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:18:07 SEP 19, 1972 *
GRAPHLOT, VERSION 1.0, P.F. LANDECKO
PLOT LINE 5804, ELEMENTS 905-965

V/H=0.179 LOW TEMP=11.1°C AT=36.6°C FILTER SELECT=1 3.557/SEC/ELEMENT

SEGMENT 0 OF 1

CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE= 1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH +'S) AND CHANNEL 2

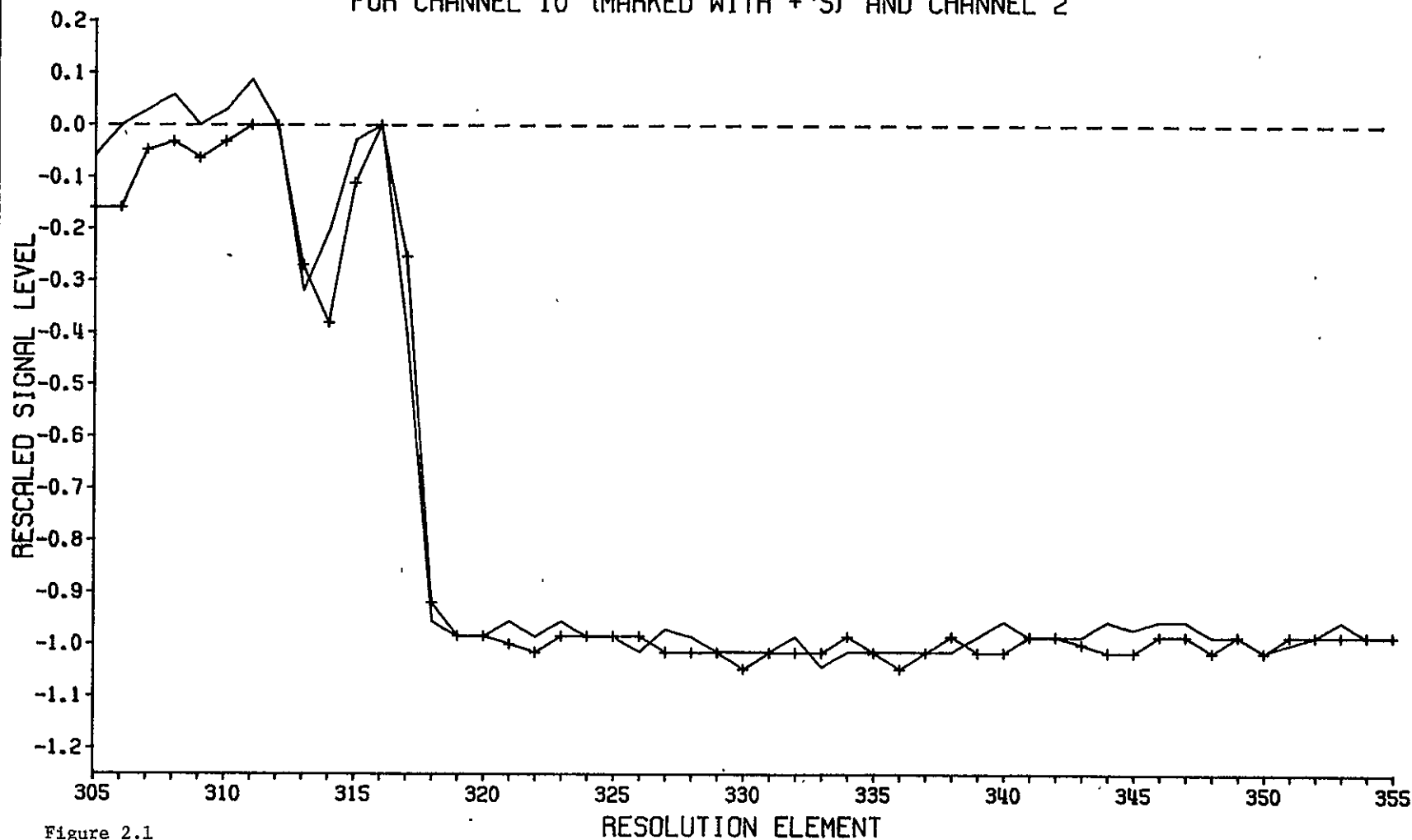


Figure 2.1

HSS158-72-C, F3 L2 R18 (CLEAN) 0.5K, PANELS, ETC. ON RAMP 08/15/72

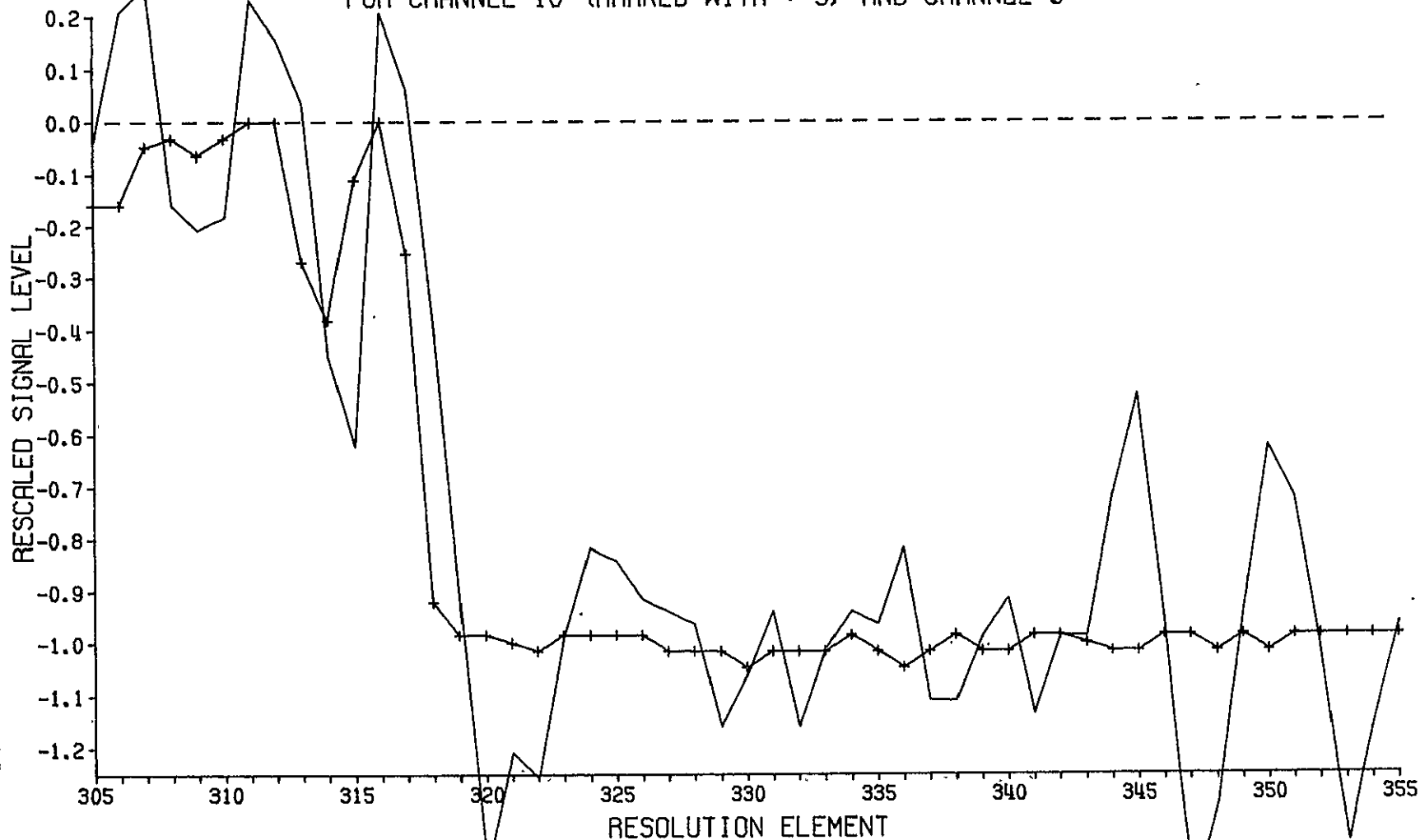
* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:20:17 SEP 18, 1972 *
DRAWPLOT, VERSION 1.0, P.F. LANDECKU
PLOT LINE 5604, ELEMENTS 305-355

V/H=0.178 LOW TEMP=+11.1°C $\Delta T=36.6^\circ\text{C}$ FILTER SELECT=1 9.557 $\mu\text{SEC/ELEMENT}$

SEGMENT 0 OF 1

CHANNEL 3: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 3



HSS158-72-C, F3 L2 R19 CLEAR 0.5K, PANELS, ETC. ON RAMP (R8/15/72)

V/H=0.178 LOW TEMP=+11.1°C $\Delta T=36.6^\circ\text{C}$ FILTER SELECT=1 9.5574SEC/ELEMENT

SEGMENT 0 OF 1

CHANNEL 4: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:22:00 SEP 19, 1972 *

DRAMPLOT, VERSION 1.0, P.F. LANBECK

PLOT LINE 5604, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 4

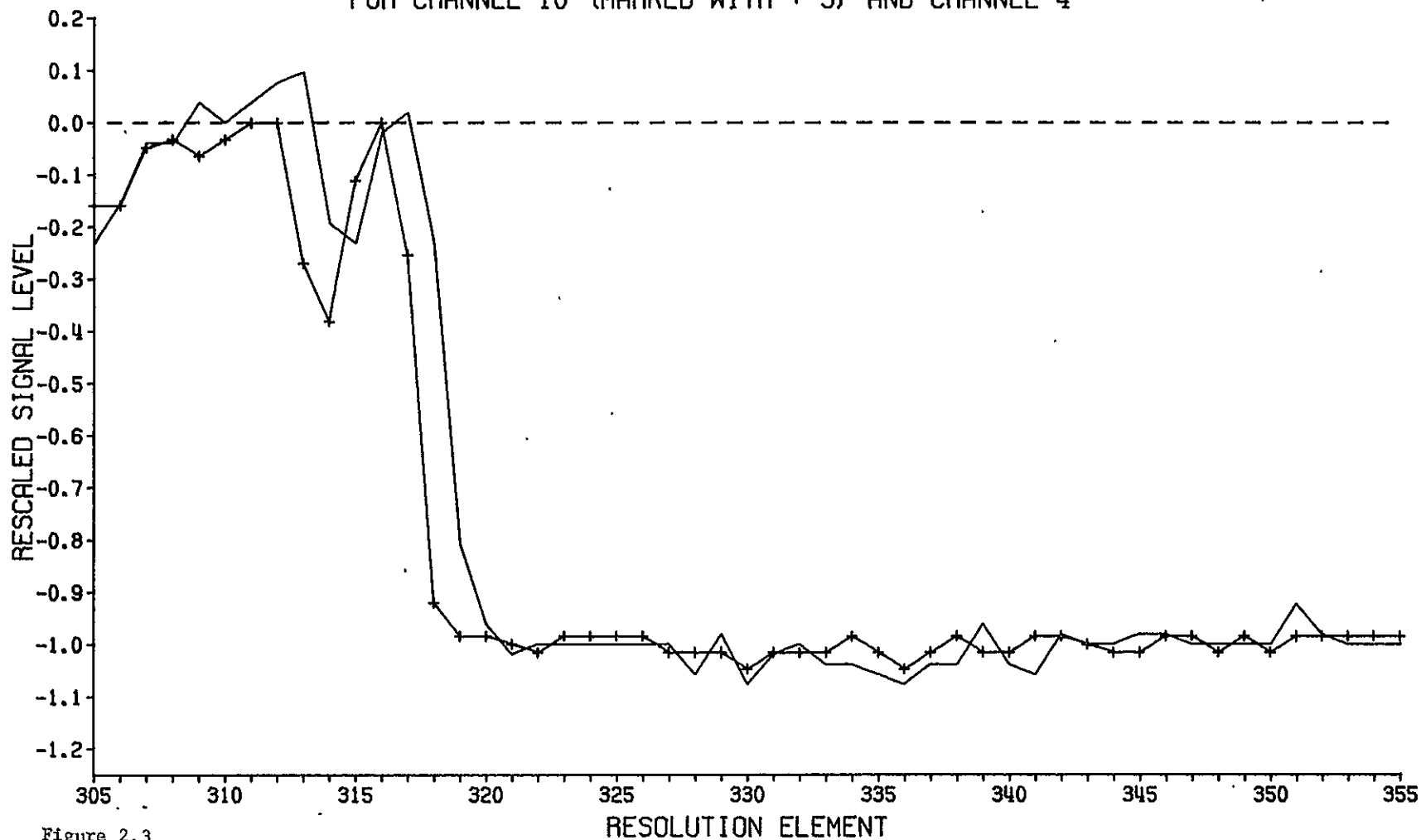


Figure 2.3

Figure 2.4

HSS156-72-C, F3 L2 R19 (CLEAR) 0.5K, PANELS, ETC, ON RAMP (06/15/72)

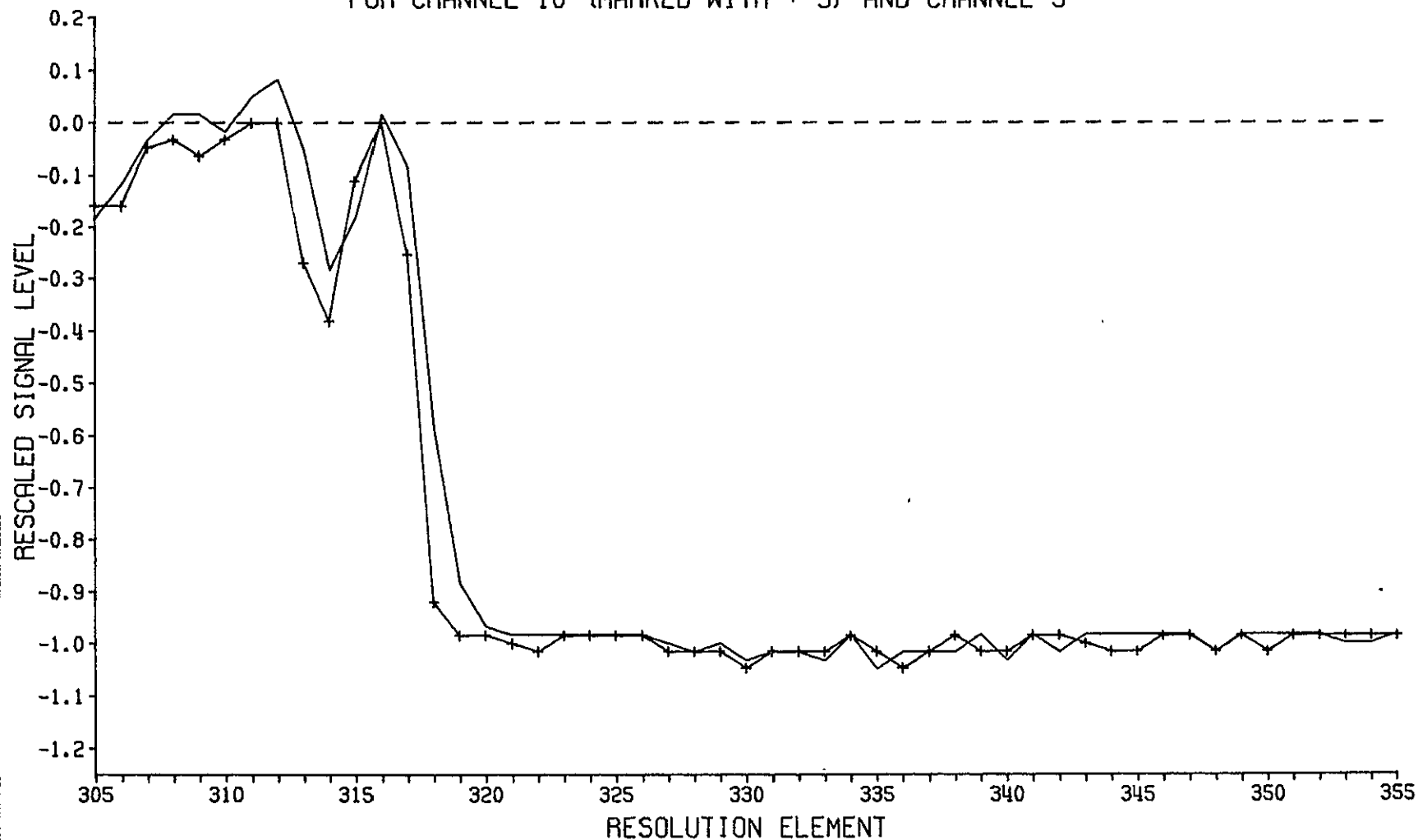
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PLOT LINE 5604, ELEMENTS 305-355

V/M=0.179 LOW TEMP=-11.1°C $\Delta T=38.6^{\circ}\text{C}$ FILTER SELECT=1 3.557 $\mu\text{SEC/ELEMENT}$

SEGMENT 0 OF 1

CHANNEL 5: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 5



NSS168-72-C, F3 L2 A18 (CLEAN 0.5%, PANELS, ETC. ON RAMP 08/15/72)

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:26:30 SEP 18, 1972 "

V/M=0.179 LOW TEMP=-11.1°C $\Delta T=36.8^{\circ}\text{C}$ FILTER SELECT=1 3.557 $\mu\text{SEC/ELEMENT}$

GRAPHLOT, VERSION 1.0, P.F. LAMBECKI
PLOT LINE 5804, ELEMENTS 305-365

SEGMENT 0 OF 1

CHANNEL 6: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 6

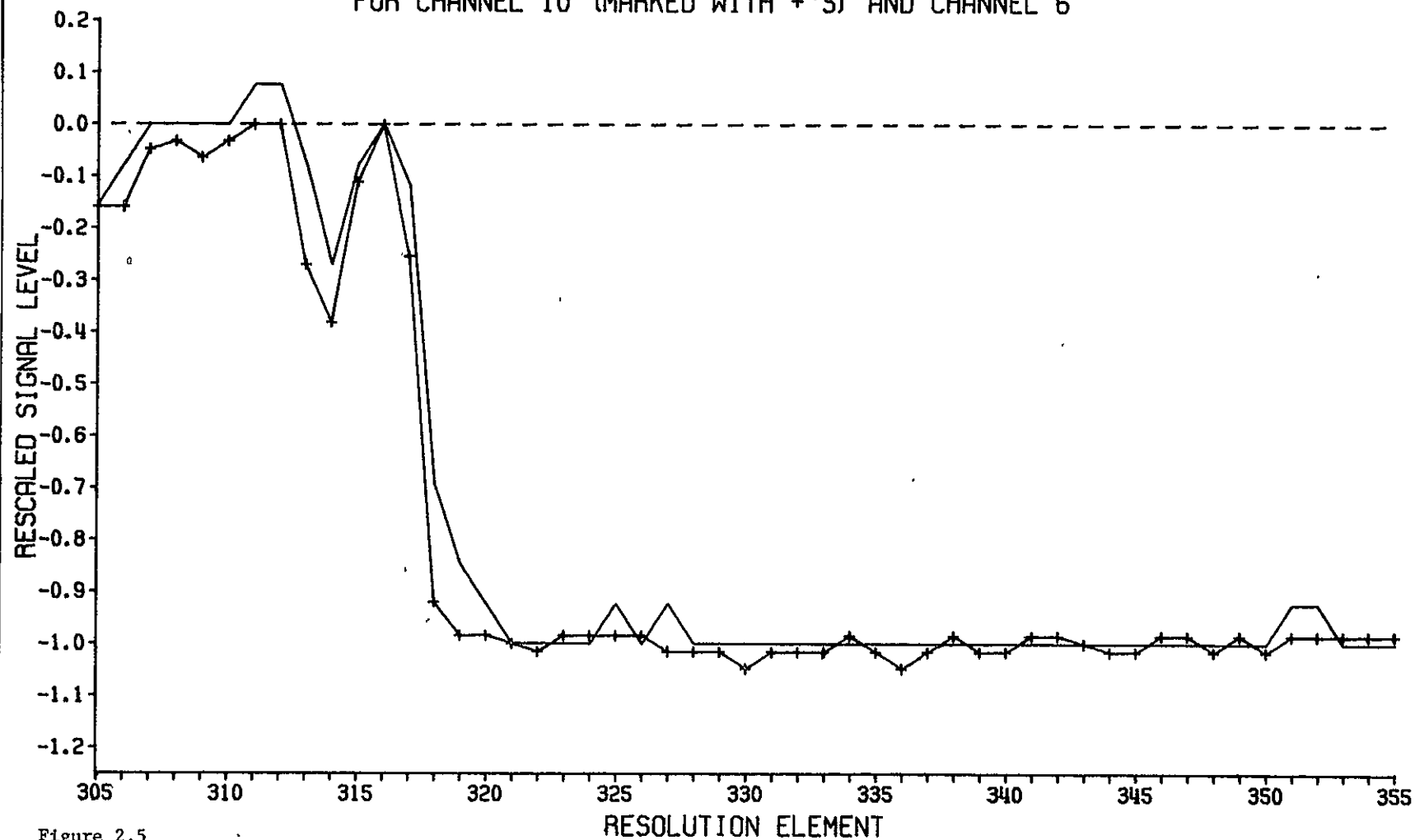


Figure 2.5

Figure 2.6

HSS156-72-C, F3 L2 R18 (CLEAR) 0.5K, PANELS, ETC. ON RAMP (06/15/72)

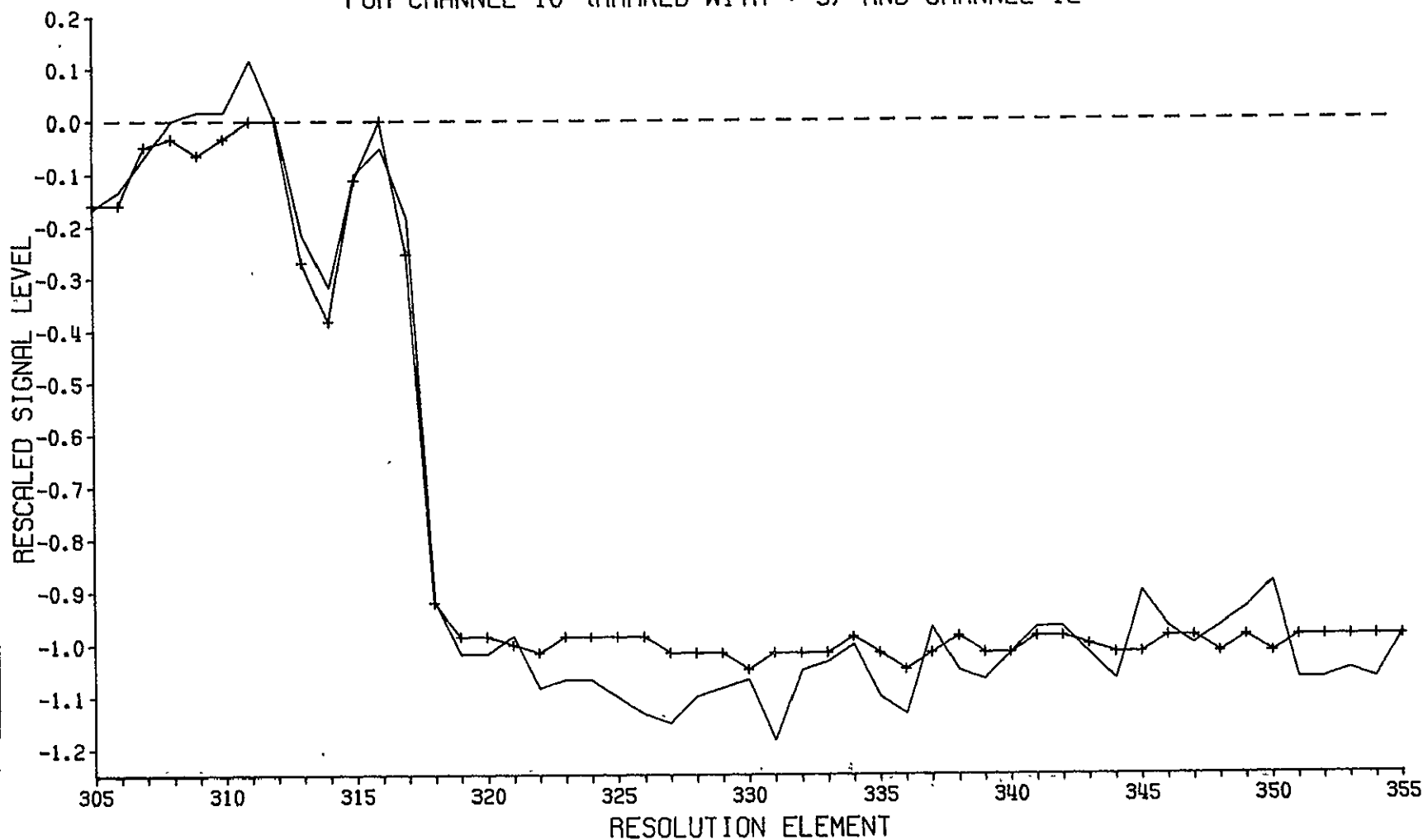
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DRAWPLOT, VERSION 1.0, P.F. LAMBECK
PLOT LINE 5604, ELEMENTS 305-355

V/H=0.179 LOW TEMP=+11.1°C $\Delta T=36.6^\circ\text{C}$ FILTER SELECT=1 9.5574SEC/ELEMENT

SEGMENT 0 OF 1

CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 12: CAL 2, SCALE=1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 12



MS156-72-C, F3 L2 R18 (CLEAR) 0.5K, PANELS, ETC, ON RAMP 08/15/72

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:36:34 SEP 19, 1972 *
GRAMPLOT, VERSION 1.0, P.F. LANGEDIG
PLOT LINE 5604, ELEMENTS 305-355

V/H=0.179 LOW TEMP=11.1°C $\Delta T=36.6^\circ\text{C}$ FILTER SELECT=1 3.557 $\mu\text{SEC/ELEMENT}$

SEGMENT 0 OF 1

CHANNEL 10: CAL 2, SCALE= 1X, OFFSET=1 CHANNEL 13: CAL 2, SCALE= 1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 13

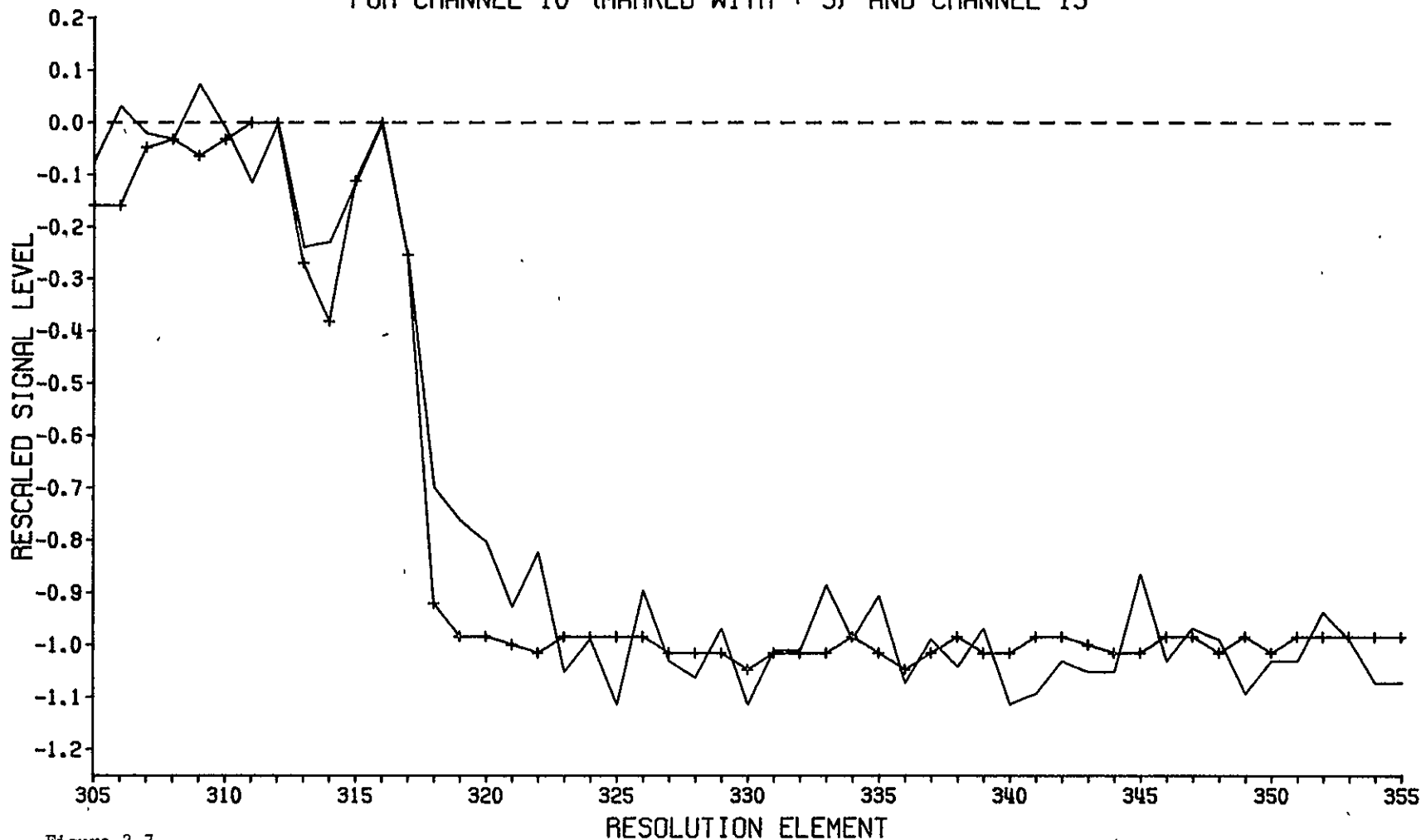


Figure 2.7

Figure 2.8

MSS156-72-C, F3 L2 R18 (CLEAR) 0.5K, PANELS, ETC, ON RAMP (06/15/72)

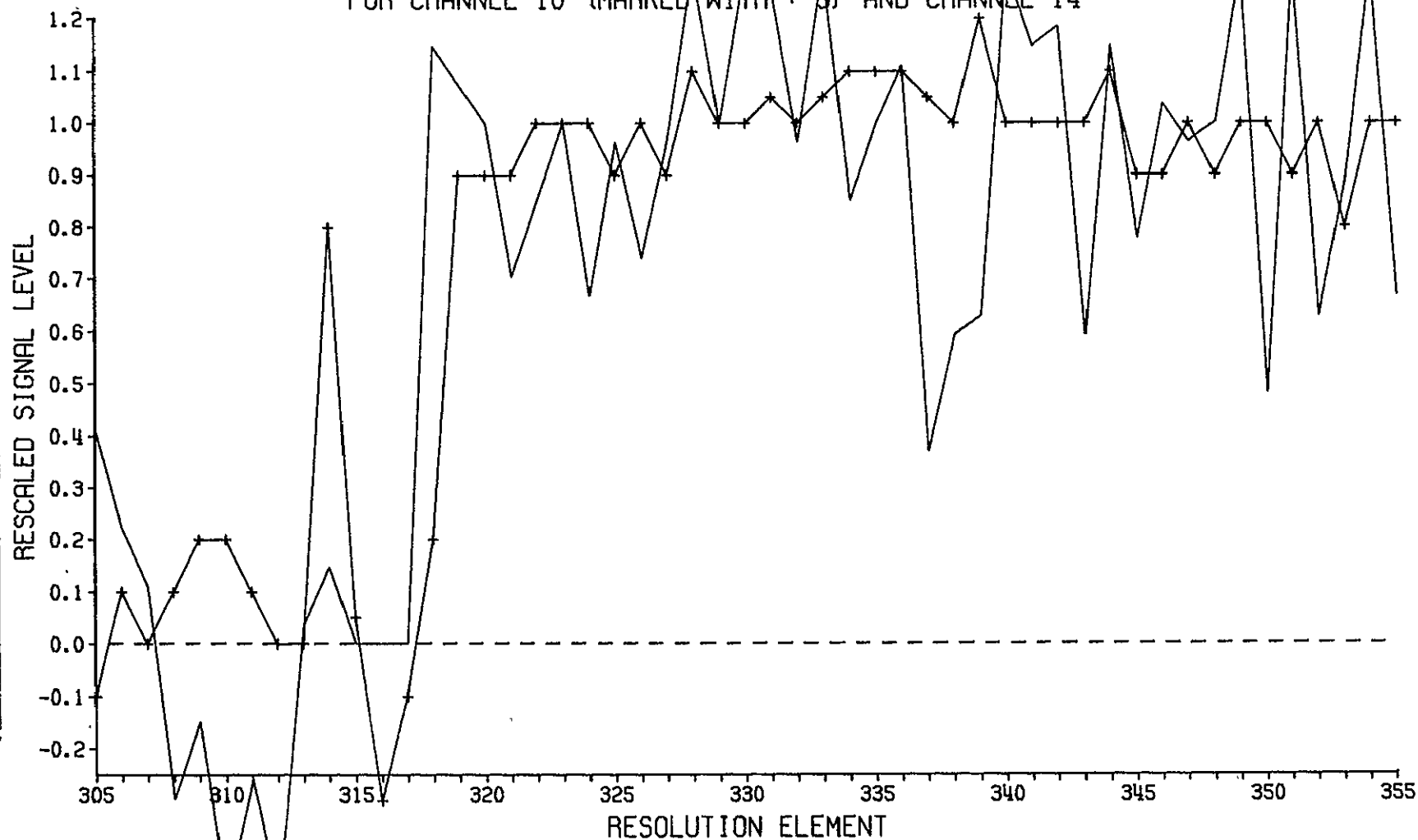
* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 10:52:44 SEP 18, 1972 *
(DRAWPLOT, VERSION 1.0, P.F. LAMBECK)
PLOT LINE 5572, ELEMENTS 305-355

V/H=0.178 LOW TEMP=+11.1°C $\Delta T=36.6^\circ\text{C}$ FILTER SELECT=1 3.557 $\mu\text{SEC/ELEMENT}$

SEGMENT 0 OF 1

CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 14: CAL 1, SCALE=1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 32% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+') AND CHANNEL 14



HSS158-72-C, F3 L2 R19 MCLERN 0.5K, PANELS, ETC. ON RAMP 10/6/15/72)

V/A=0.179 LOW TEMP=11.1°C $\Delta T=36.0^\circ\text{C}$ FILTER SELECT=1 3.557/SEC/ELEMENT

SEGMENT 0 OF 1

CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 15: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:37:46 SEP 19, 1972 *

GRAPHLOT, VERSION 1.0, P.F. LANBECK

PLOT LINE 5604, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 15

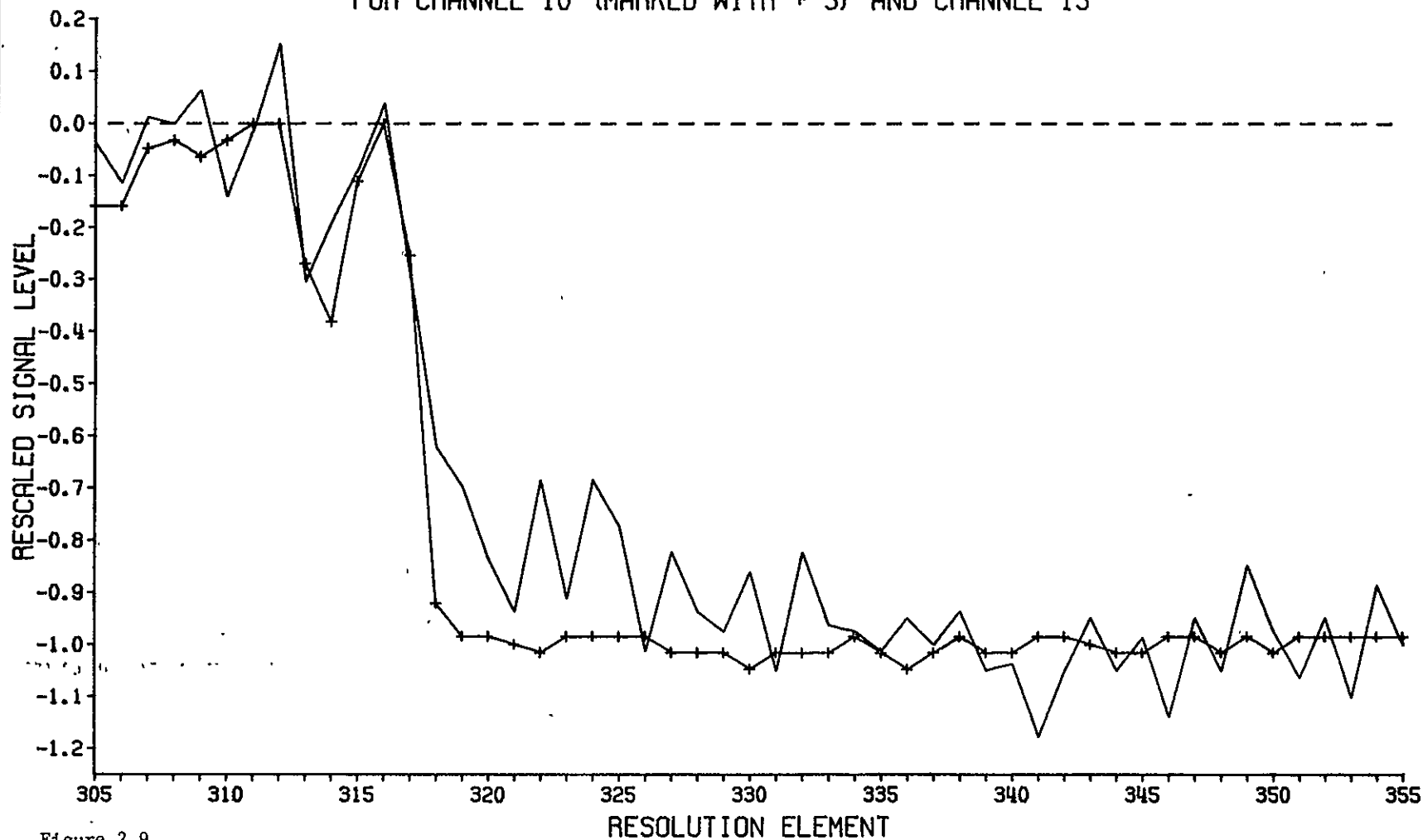


Figure 2.9

Figure 2.10

HSS156-72-C, F3 L2 R19 (CLEAR) 0.5K, PANELS, ETC, ON RAMP (06/15/72)

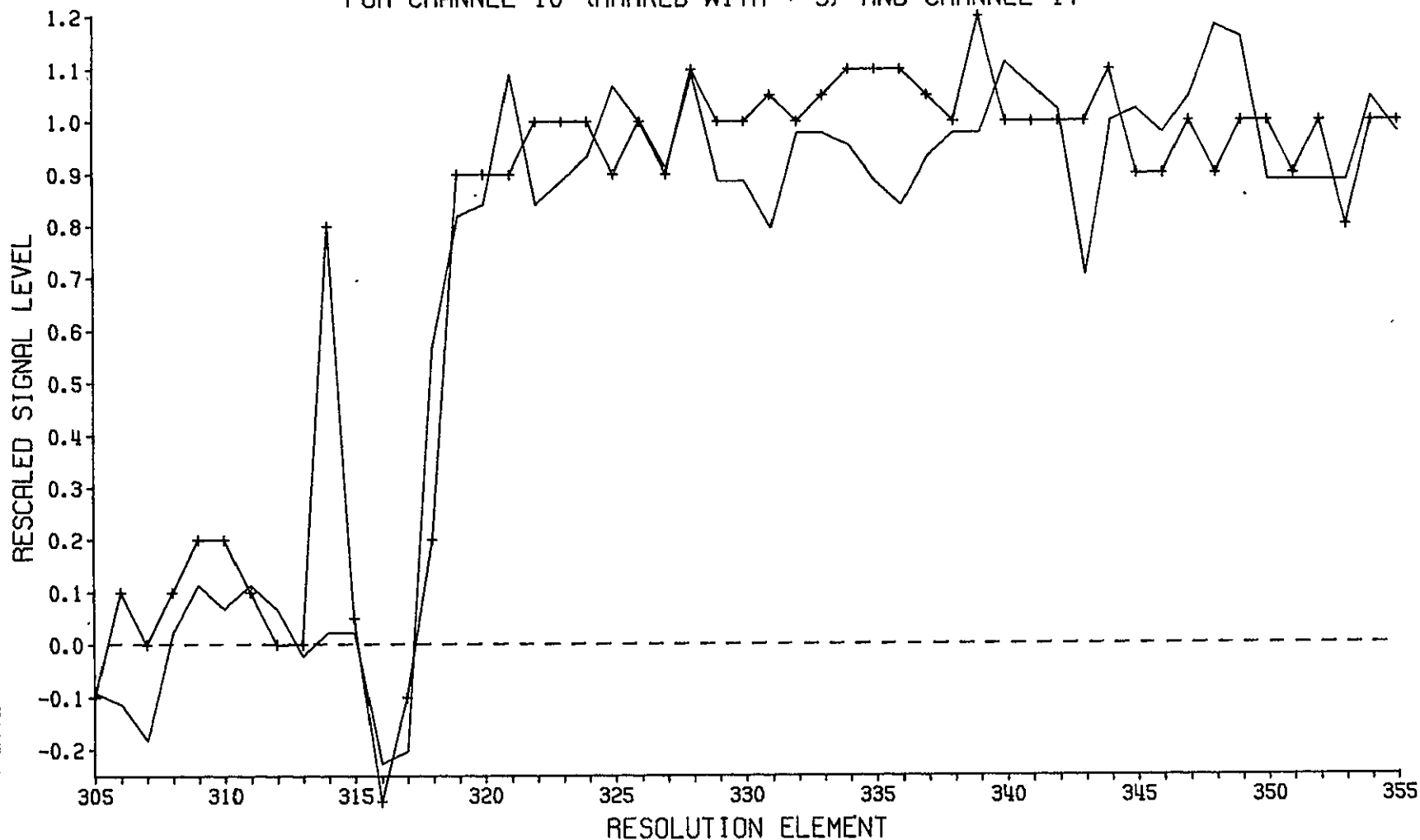
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DRAMPLOT, VERSION 1.0, P.F. LANGBECK
PLOT LINE 5572, ELEMENTS 305-355

V/M=0.179 LOW TEMP=-11.1°C $\Delta T=36.6^{\circ}\text{C}$ FILTER SELECT=1 3.557 $\mu\text{SEC/ELEMENT}$

SEGMENT 0 OF 1

CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 17: CAL 1, SCALE=1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 32% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH +'S) AND CHANNEL 17



NSS156-72-C, F9 L2 R19 (CLEAR) 0.5K, PANELS, ETC. ON RAMP (R8/15/72)

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:39:20 SEP 19, 1972 *
DRAWPLOT, VERSION 1.0, P.F. LAMBECK
PLOT LINE 5604, ELEMENTS 305-355

V/H=0.179 LOW TEMP=-11.1°C $\Delta T=36.6^\circ\text{C}$ FILTER SELECT=1 9.557/SEC/ELEMENT

SEGMENT 0 OF 1

CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 21: CAL 1, SCALE=1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 21

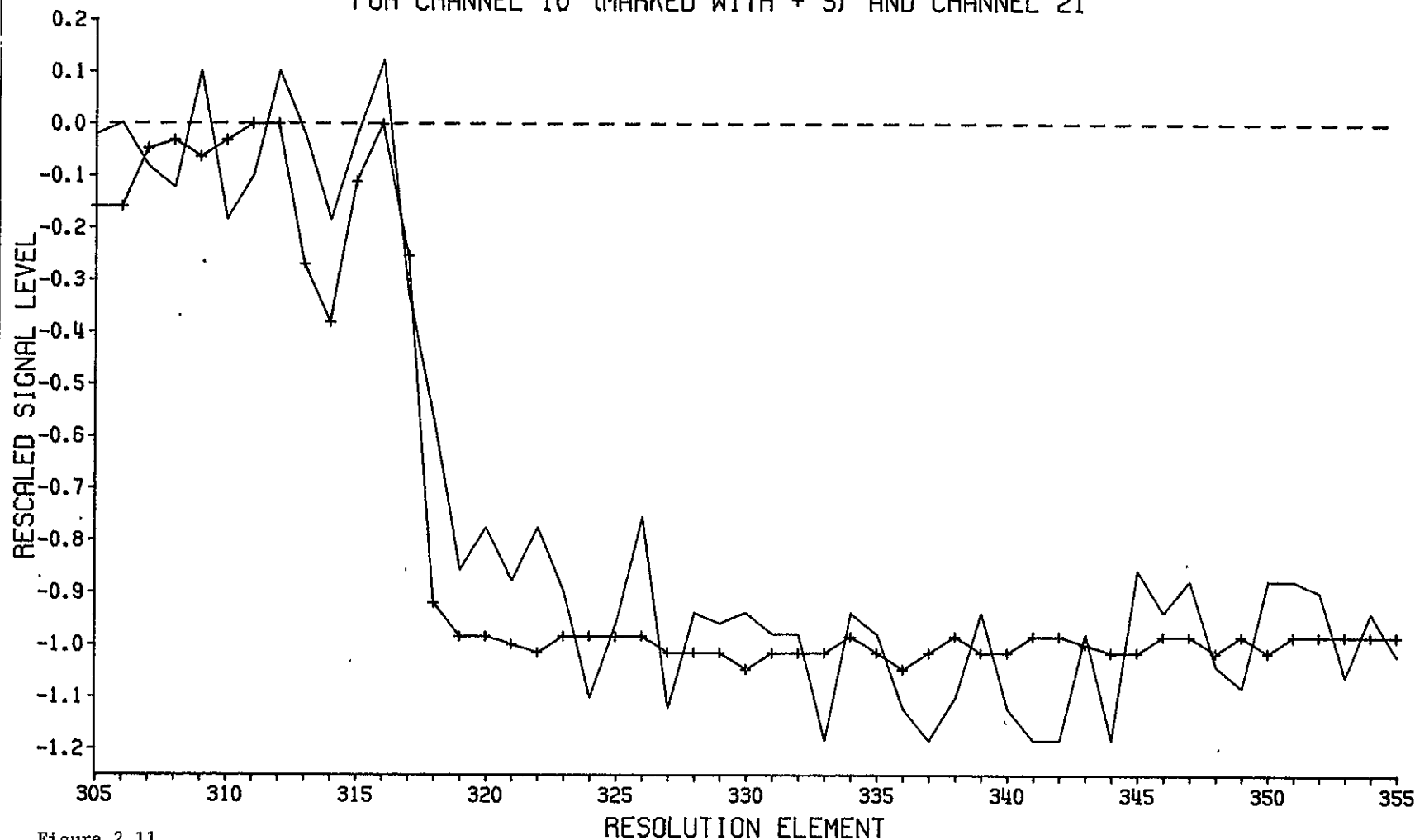


Figure 2.11

Figure 2.12

HSS156-72-C, F3 L2 R18 (CLEAR) 0.5K, PANELS, ETC. ON RAMP (06/15/72)

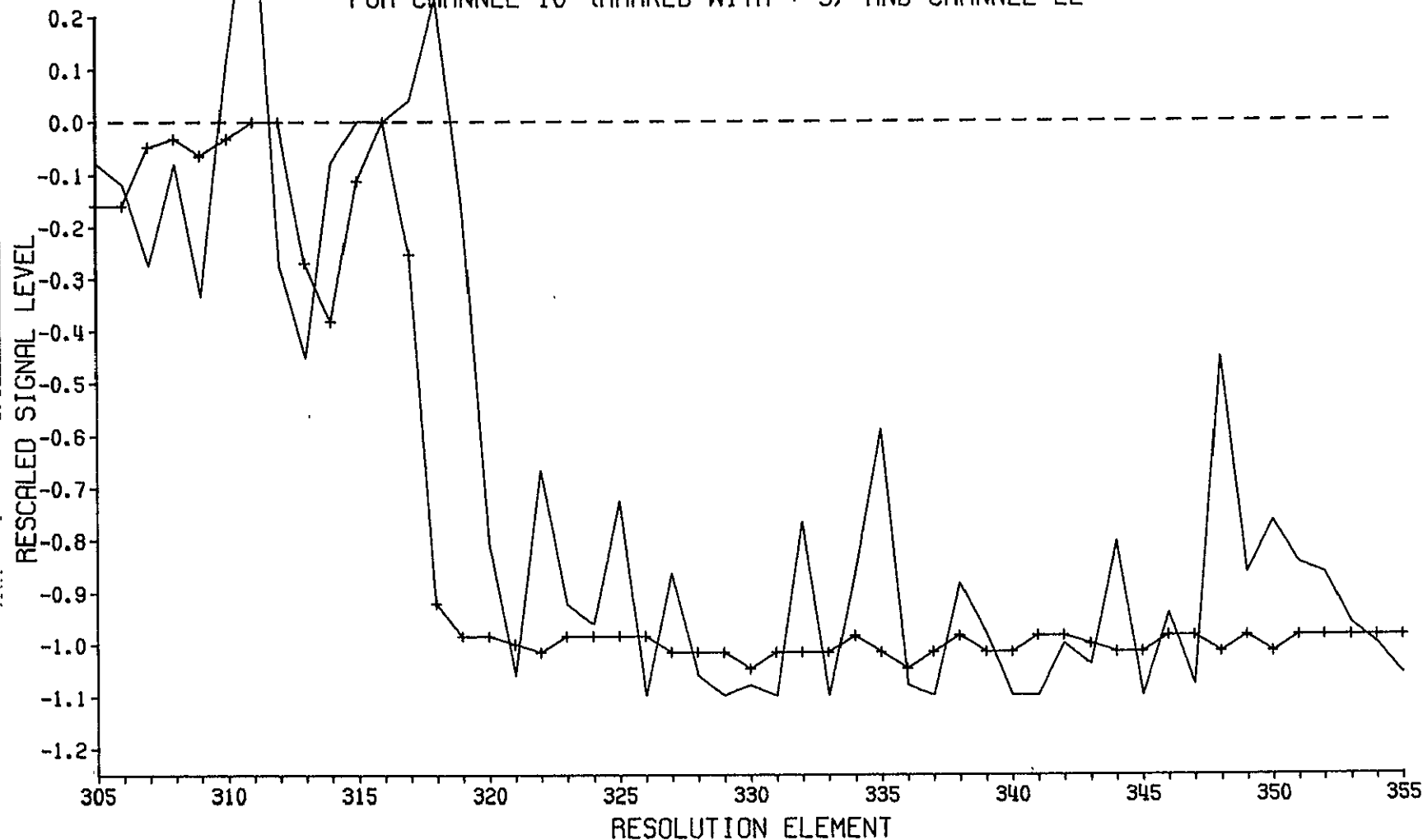
* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:40:27 SEP 19, 1972 *
GRAPHLOT, VERSION 1.0, P.F. LAMBECK
PLOT LINE 5604, ELEMENTS 305-355

V/H=0.179 LOW TEMP=+11.1°C $\Delta T=38.6^\circ\text{C}$ FILTER SELECT=1 9.557/SEC/ELEMENT

SEGMENT 0 OF 1

CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 22: CAL 1, SCALE=1X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING CONCRETE AND 4% GRAY PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 22



HSS166-72-C, F3 L2 R7 (CLEAR) 3.4K, PANELS, ETC, ON RAMP (08/15/72)
 06/04/72 16:17:54.6, RADAR ALT 03390 FT, TRUE HEADING 179.4°, DRIFT +04.3°
 V/H=0.0007 LOW TEMP=-10.9°C $\Delta T=36.7^\circ\text{C}$ FILTER SELECT=1 7.958 $\mu\text{SEC/ELEMENT}$
 SEGMENT 0 OF 1
 CHANNEL 2: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:12:24 SEP 20, 1972 "
 DRAWPLOT, VERSION 1.0, P.F. LAMBECK
 PLOT LINE 1364, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
 CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
 FOR CHANNEL 10 (MARKED WITH +'S) AND CHANNEL 2

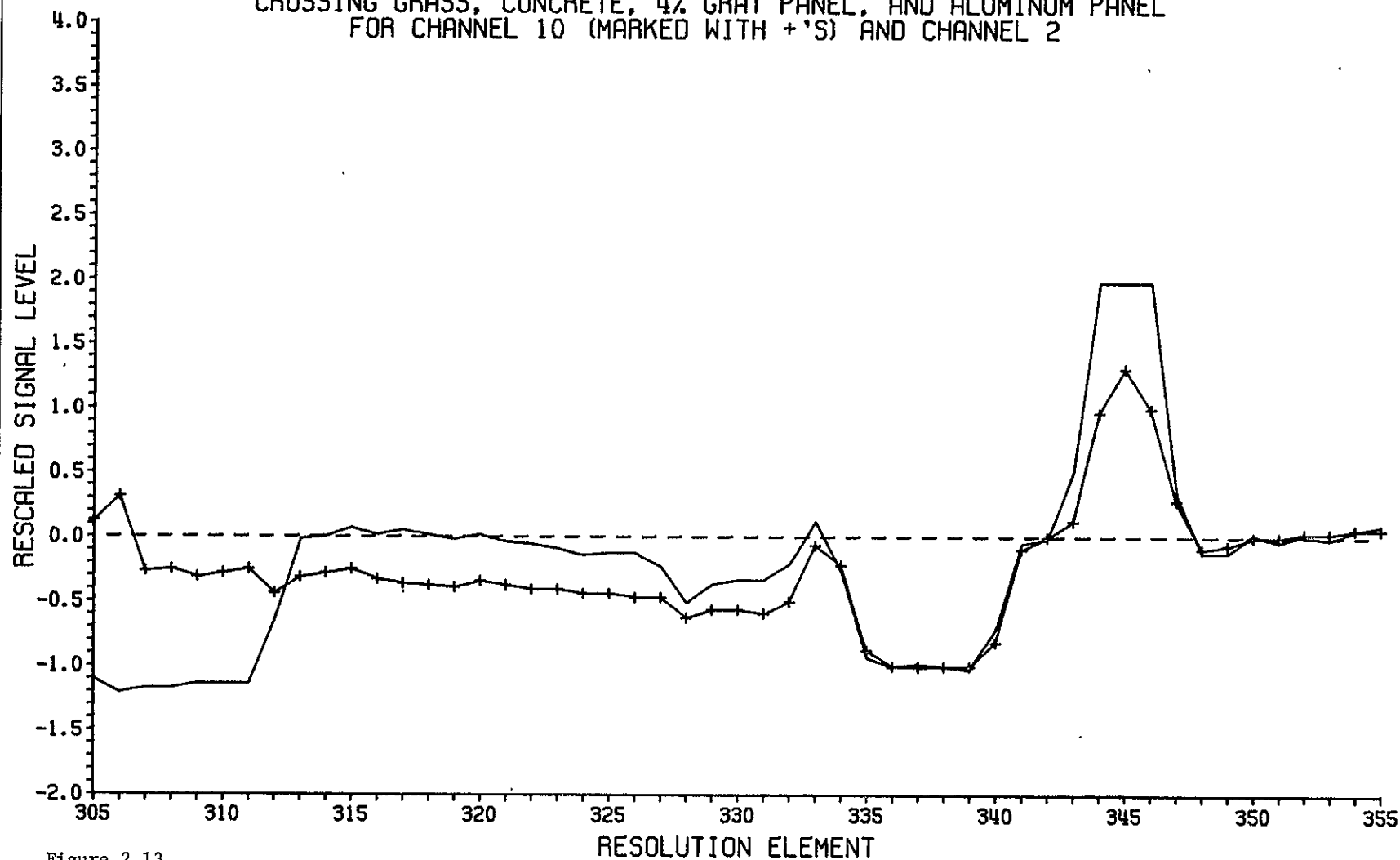


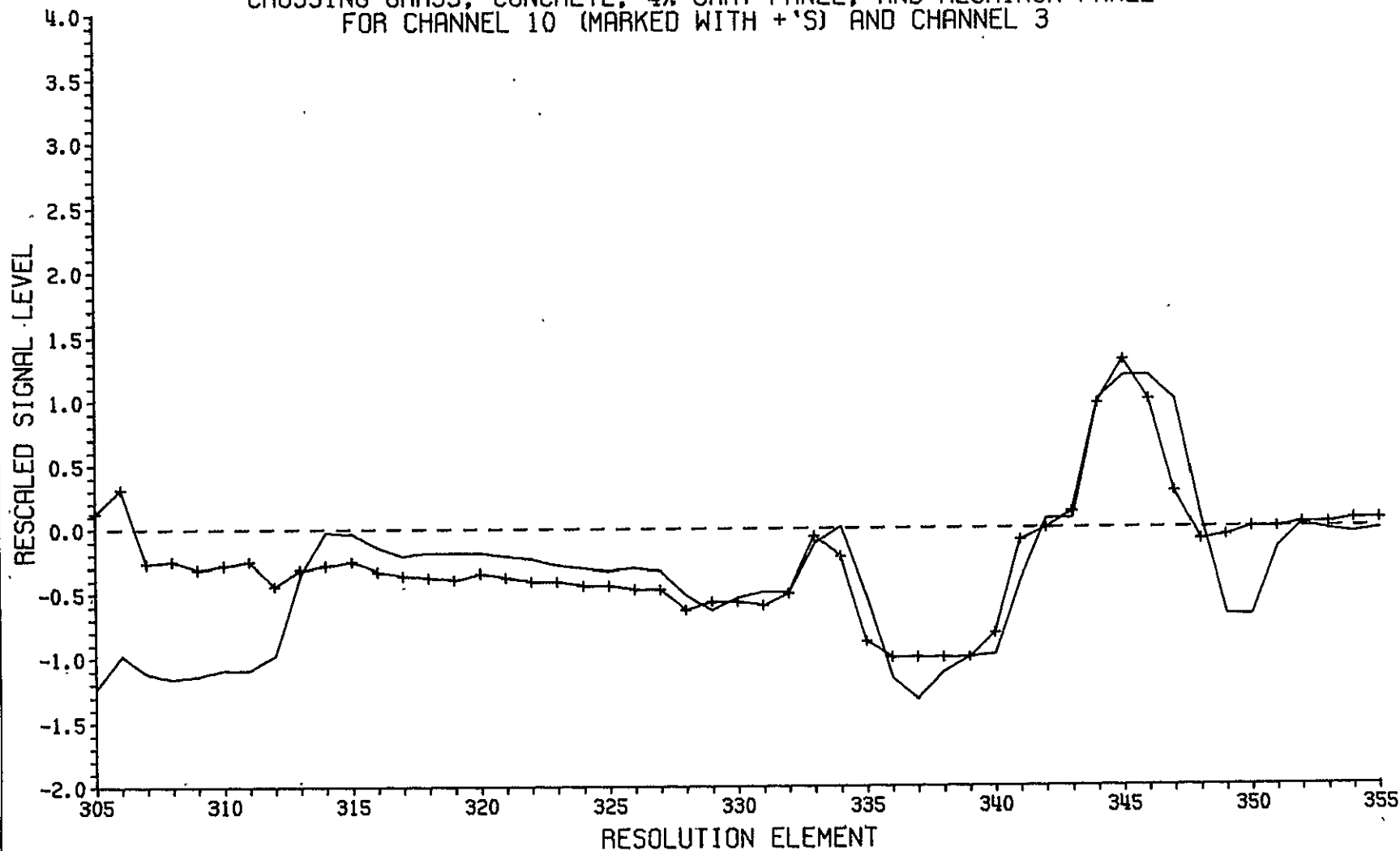
Figure 2.13

Figure 2.14

MSS156-72-C, F3 L2 R7 (CLEAR) 3.4K, PANELS, ETC, ON RAMP (06/15/72)
06/04/72 16:17:54.6, RADAR ALT 03390 FT, TRUE HEADING 179.4°, DRIFT +04.3°
V/H=0.0887 LOW TEMP=-10.8°C ΔT=36.7°C FILTER SELECT=1 7.858μSEC/ELEMENT
SEGMENT 0 OF 1
CHANNEL 3: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:13:32 SEP 20, 1972 *
GRAMPLOT, VERSION 1.0, P.F. LAMBECKO
PLOT LINE 1364, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 3



MSS166-72-C, F3 L2 R7 (CLEAR 3.4X, PANELS, ETC. ON RAMP 08/15/72)
 06/04/72 16:17:54.6, MAGN ALT 03390 FT, TRUE HEADING 178.4°, DRIFT +04.3°
 Y/H=0.0067 LON TEMP=+10.8°C ΔT=38.7°C FILTER SELECT=1 7.858/SEC/ELEMENT
 SEGMENT 0 OF 1
 CHANNEL 4: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:14:42 SEP 20, 1972 *
 (GRAMPLOT, VERSION 1.0, P.F. LAMBECK)
 PLOT LINE 1384, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
 CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
 FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 4

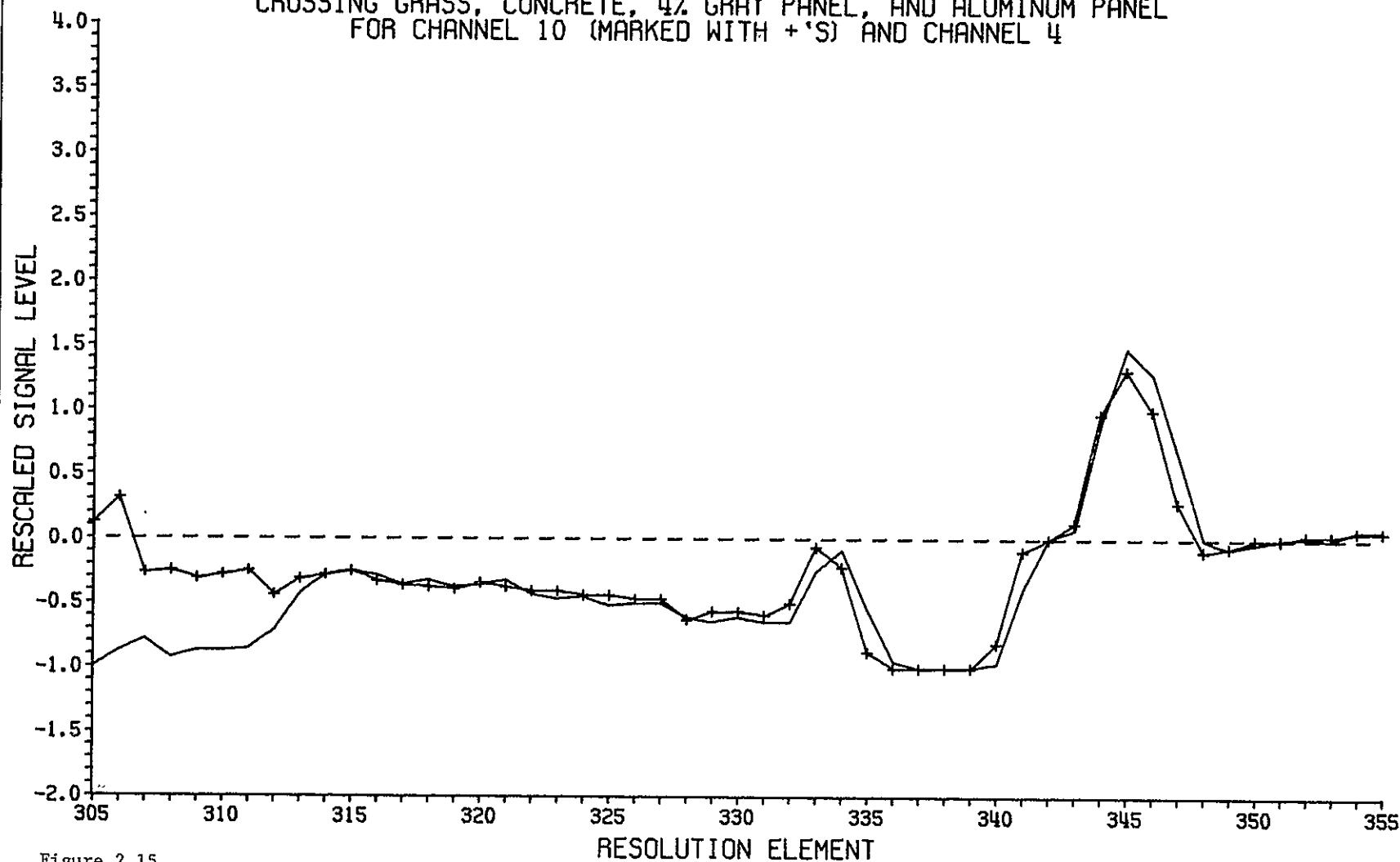


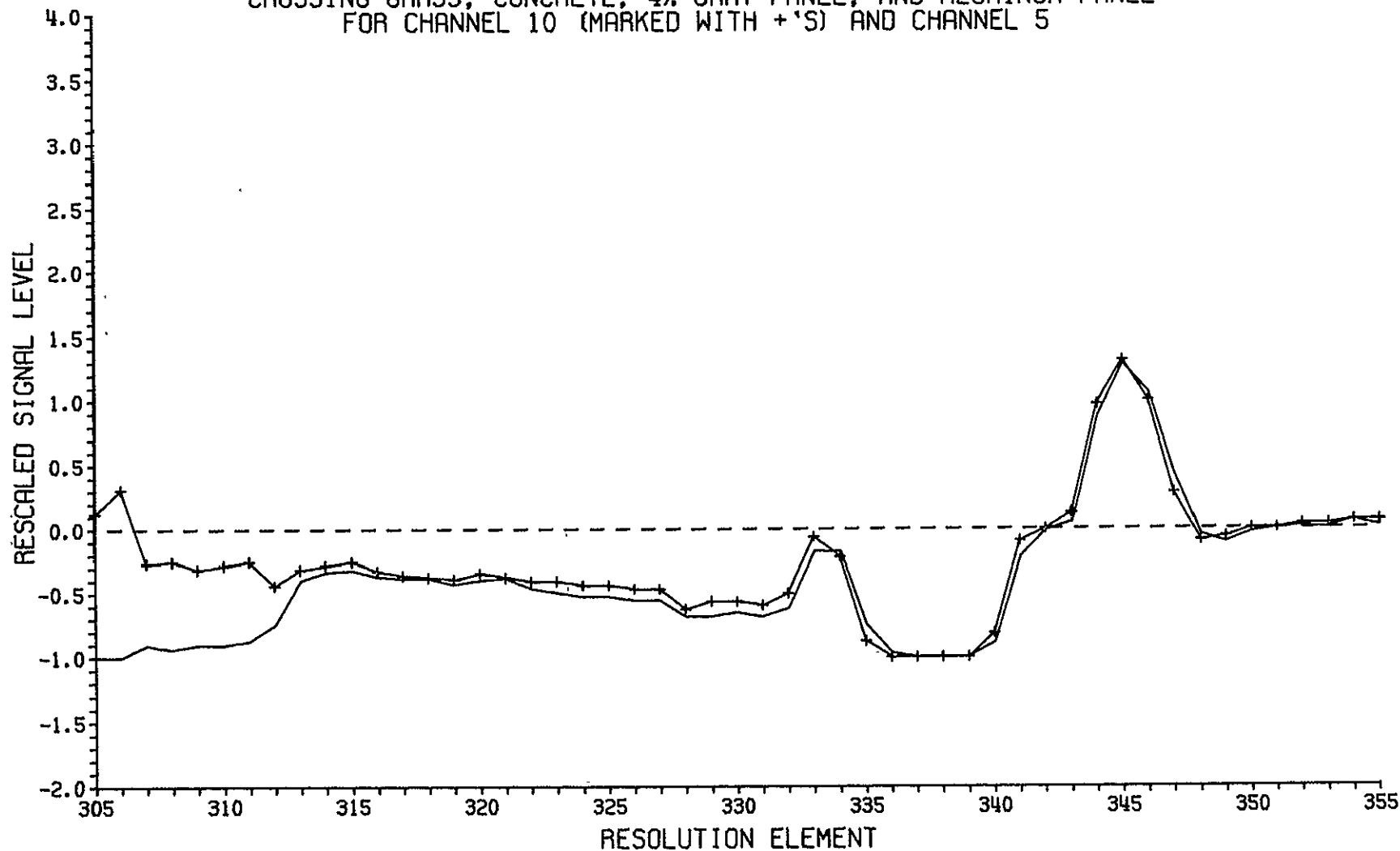
Figure 2.15

Figure 2.16

MSS158-72-C, F3 L2 A7 (CLEAN) 3.4K, PANELS, ETC. ON RAMP (06/15/72)
 06/04/72 16:17:54.6, RADAR ALT 03390 FT, TRUE HEADING 179.4°, DRIFT +04.3°
 V/H=0.0887 LOW TEMP=-10.9°C ΔT=38.7°C FILTER SELECT=1 7.958μSEC/ELEMENT
 SEGMENT 0 OF 1
 CHANNEL 5: CAL 2, SCALE= 1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:16:20 SEP 20, 1972 *
 (DRAWPLOT, VERSION 1.0, P.F. LAMBECK)
 PLOT LINE 1364, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
 CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
 FOR CHANNEL 10 (MARKED WITH +'S) AND CHANNEL 5



MSS156-72-C, F3 L2 A7 (CLEAR) 3.4K, PANELS, ETC. ON RAMP 08/15/72)
06/04/72 16:17:54.8, RADAR ALT 03390 FT, TRUE HEADING 179.4°, DRIFT +04.3°
V/H=0.0887 LON TEMP=+10.9°C $\Delta T=38.7^{\circ}\text{C}$ FILTER SELECT=1 7.9584SEC/ELEMENT
SEGMENT 0 OF 1
CHANNEL 6: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 16:17:33 SEP 20, 1972 *
DRAMPLOT, VERSION 1.0, P.F. LANBECK
PLOT LINE 1384, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
FOR CHANNEL 10 (MARKED WITH + 'S) AND CHANNEL 6

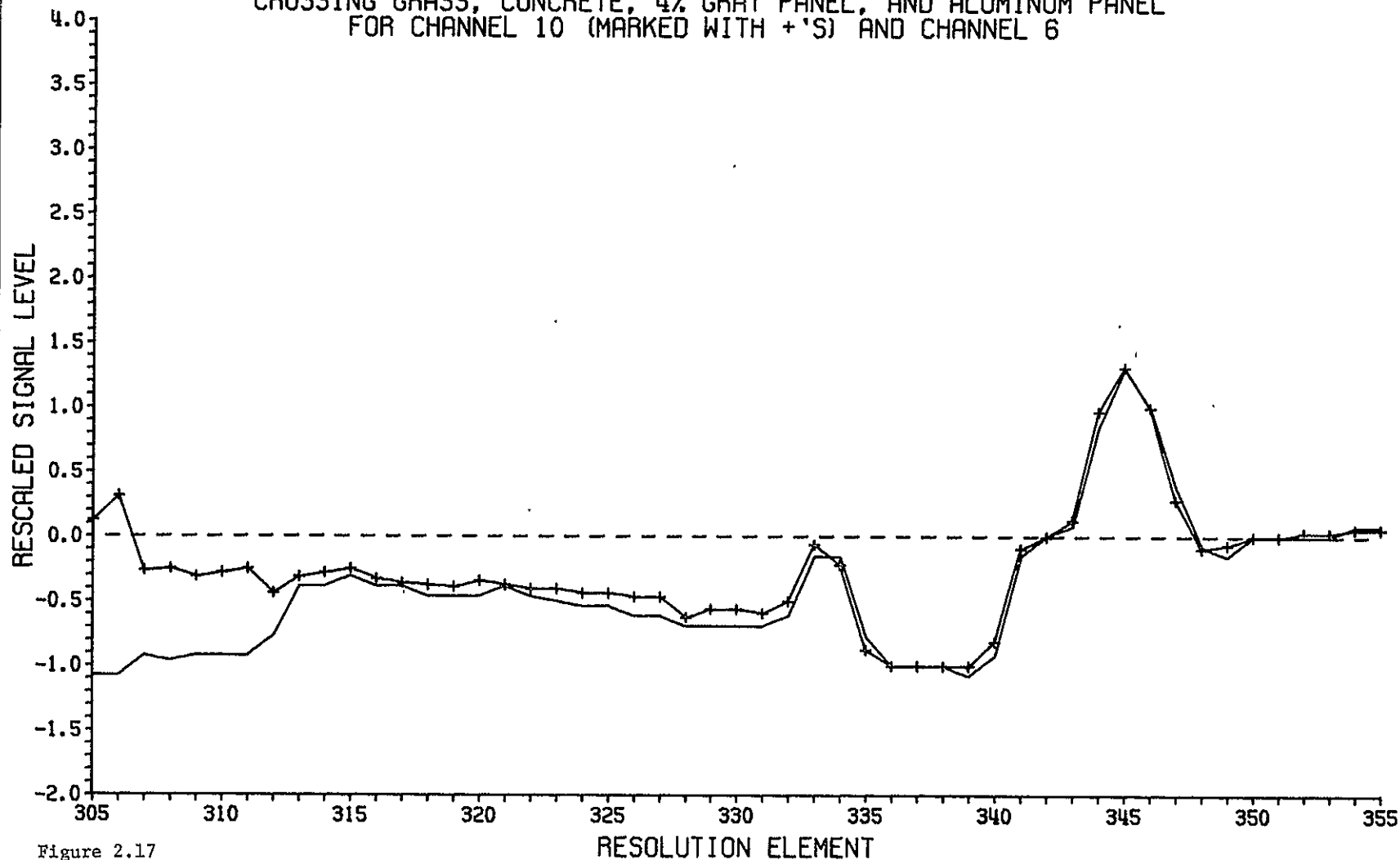


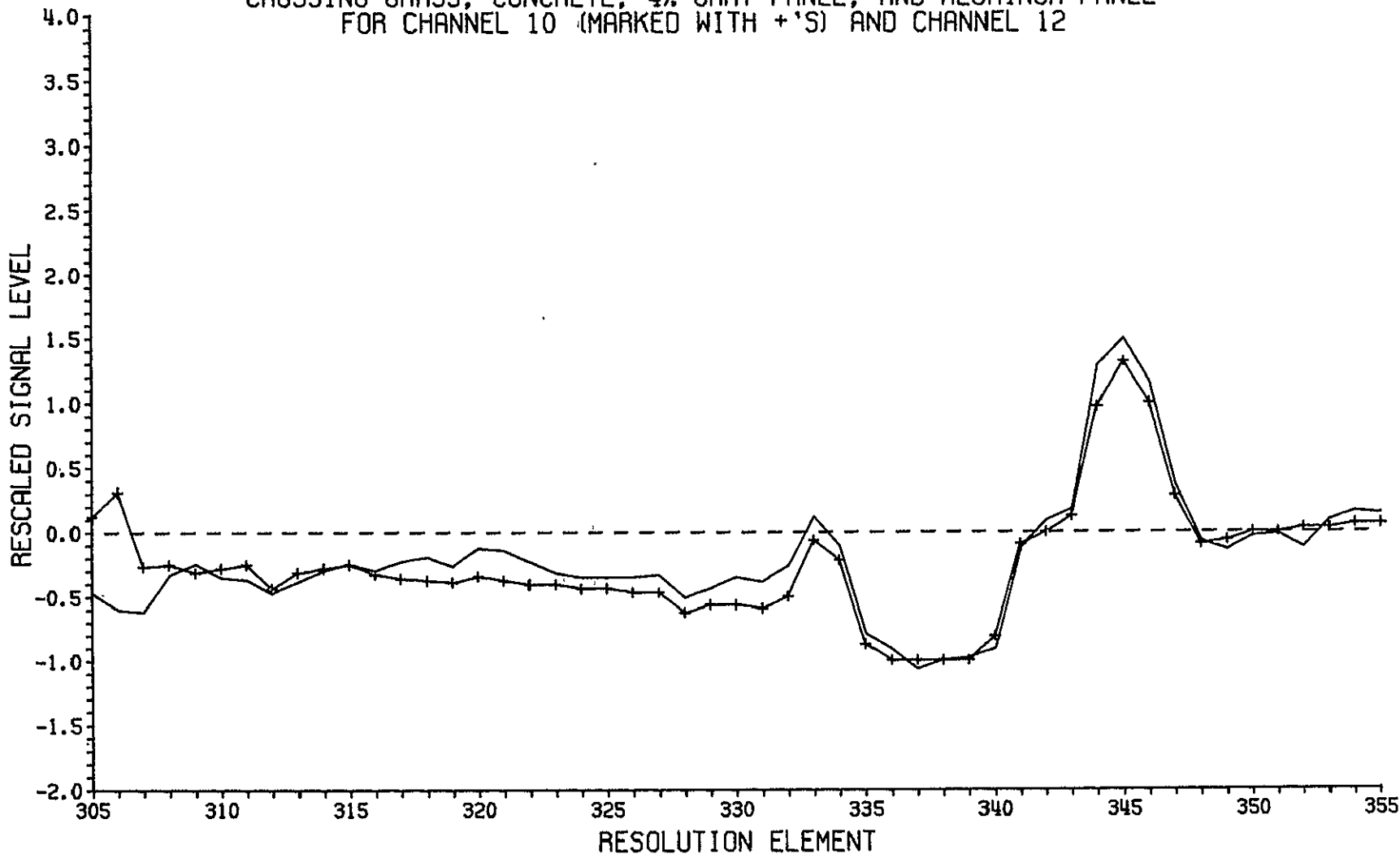
Figure 2.17

Figure 2.18

MSS158-72-C, F3 L2 R7 (CLEAR) 3.0K. PANELS, ETC. ON RAMP (06/15/72)
 06/04/72 18:17:54.6, RADAR ALT 03390 FT, TRUE HEADING 179.4°, DRIFT +04.3°
 V/H=0.0687 LOW TEMP=-10.8°C ΔT=38.7°C FILTER SELECT=1 7.858μSEC/ELEMENT
 SEGMENT 0 OF 1
 CHANNEL 10: CAL 2, SCALE= 1X, OFFSET=1 CHANNEL 12: CAL 2, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:24:59 SEP 20, 1972 *
 (DRAWPLOT, VERSION 1.0, P.F. LANBECK)
 PLOT LINE 1384, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
 CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
 FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 12



MSS158-72-C, F3 L2 A7 (CLEAR) 3.4K, PANELS, ETC. ON RAMP (08/15/72)
 08/04/72 16:17:54.8, RADAR ALT 03390 FT, TRUE HEADING 179.4°, DRIFT +04.3°
 V/M=0.0887 LON TEMP=-10.8°C ΔT=36.7°C FILTER SELECT=1 7.858μSEC/ELEMENT
 SEGMENT 0 OF 1
 CHANNEL 10: CAL 2, SCALE= 1X, OFFSET=1 CHANNEL 13: CAL 2, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:28:38 SEP 20, 1972 *
 (DRAWPLOT, VERSION 1.0, P.F. LANBECK)
 PLOT LINE 1384, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
 CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
 FOR CHANNEL 10 (MARKED WITH + 'S) AND CHANNEL 13

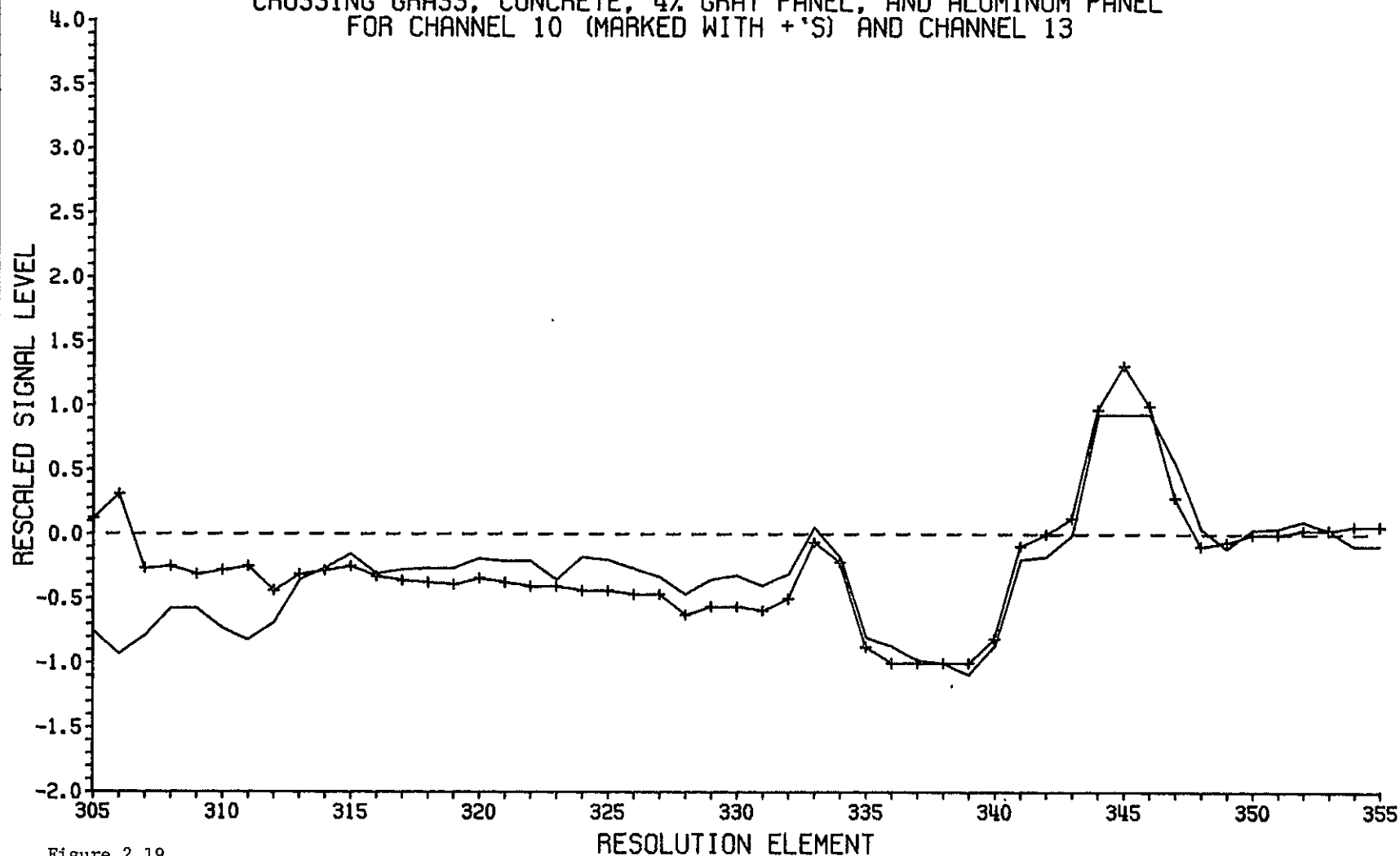


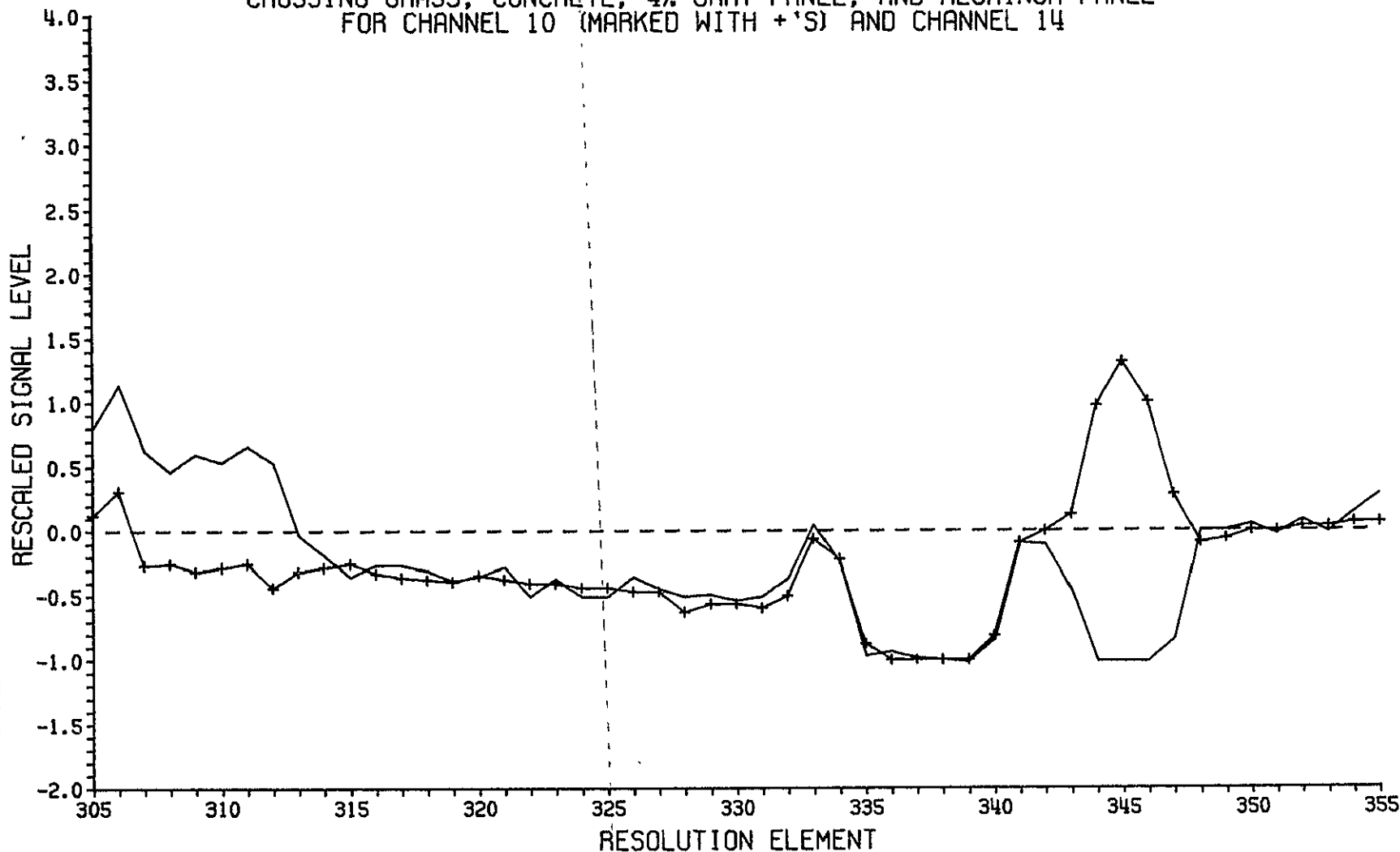
Figure 2.19

Figure 2.20

MS9158-72-C, F3 L2 A7 (CLEAR) 3.4K, PANELS, ETC, ON RAMP 06/15/72
 06/04/72 16:17:54.6, RADAR ALT 03380 FT, TRUE HEADING 178.4°, DRAFT +04.3°
 V/H=0.0687 LOW TEMP=-10.8°C ΔT=38.7°C FILTER SELECT=1 7.850/SEC/ELEMENT
 SEGMENT 0 OF 1
 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 14: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:29:07 SEP 20, 1972 *
 (DRAHPLOT, VERSION 1.0, P.F. LAMBECK)
 PLOT LINE 1364, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
 CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
 FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 14



MSS156-72-C, F3 L2 A7 (CLEAR) 3.4K, PANELS, ETC. ON RAMP 08/15/72
 08/04/72 18:17:54.8, RADAR ALT 03390 FT, TRUE HEADING 179.4°, DRIFT +04.3°
 V/H=0.0887 LOW TEMP=-10.8°C $\Delta T=38.7^{\circ}\text{C}$ FILTER SELECT=1 7.858 $\mu\text{SEC/ELEMENT}$
 SEGMENT 0 OF 1
 CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 15: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:31:21 SEP 20, 1972 *
 (DRAWPLOT, VERSION 1.0, P.F. LANBECK)
 PLOT LINE 1364, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
 CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
 FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 15

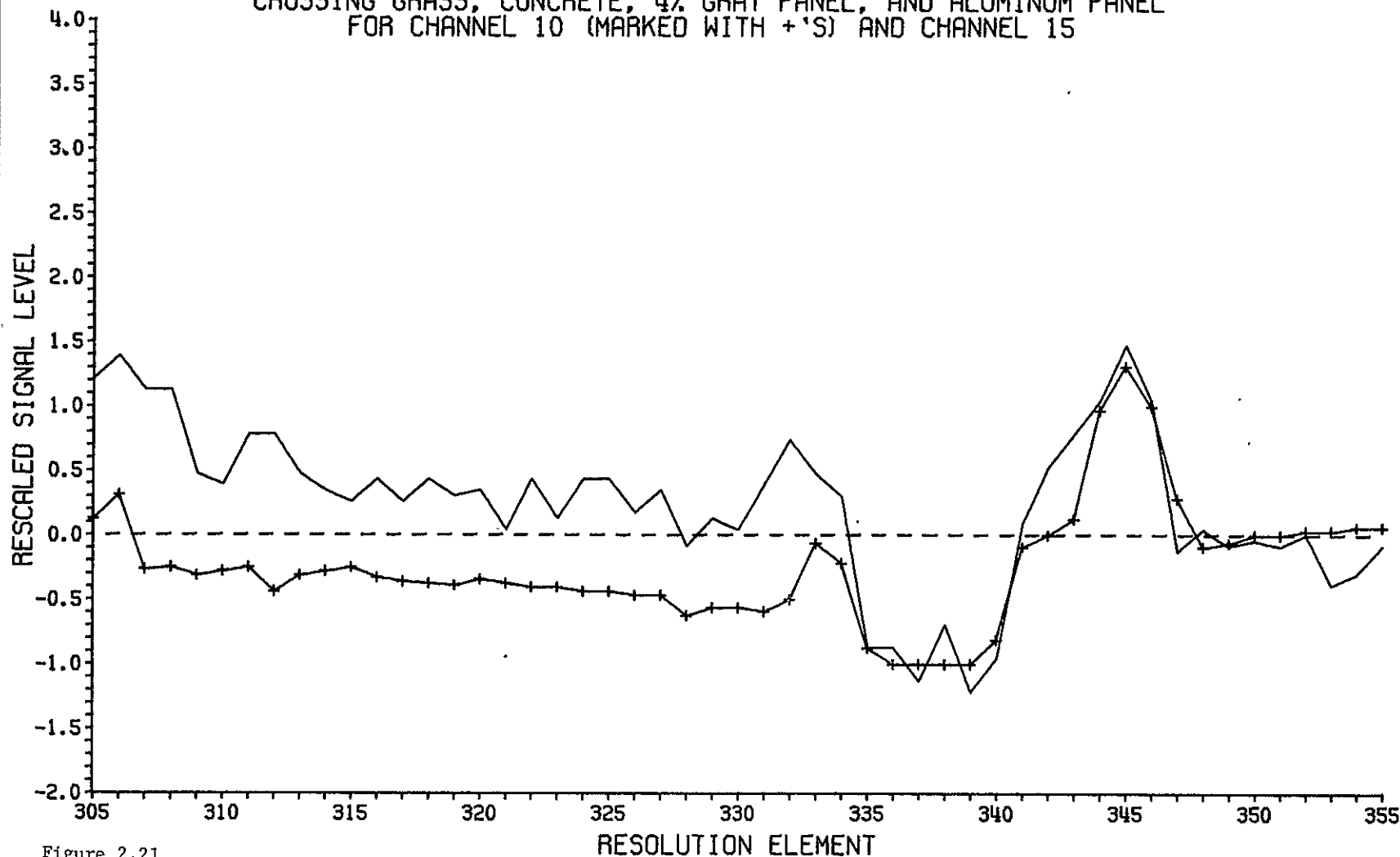


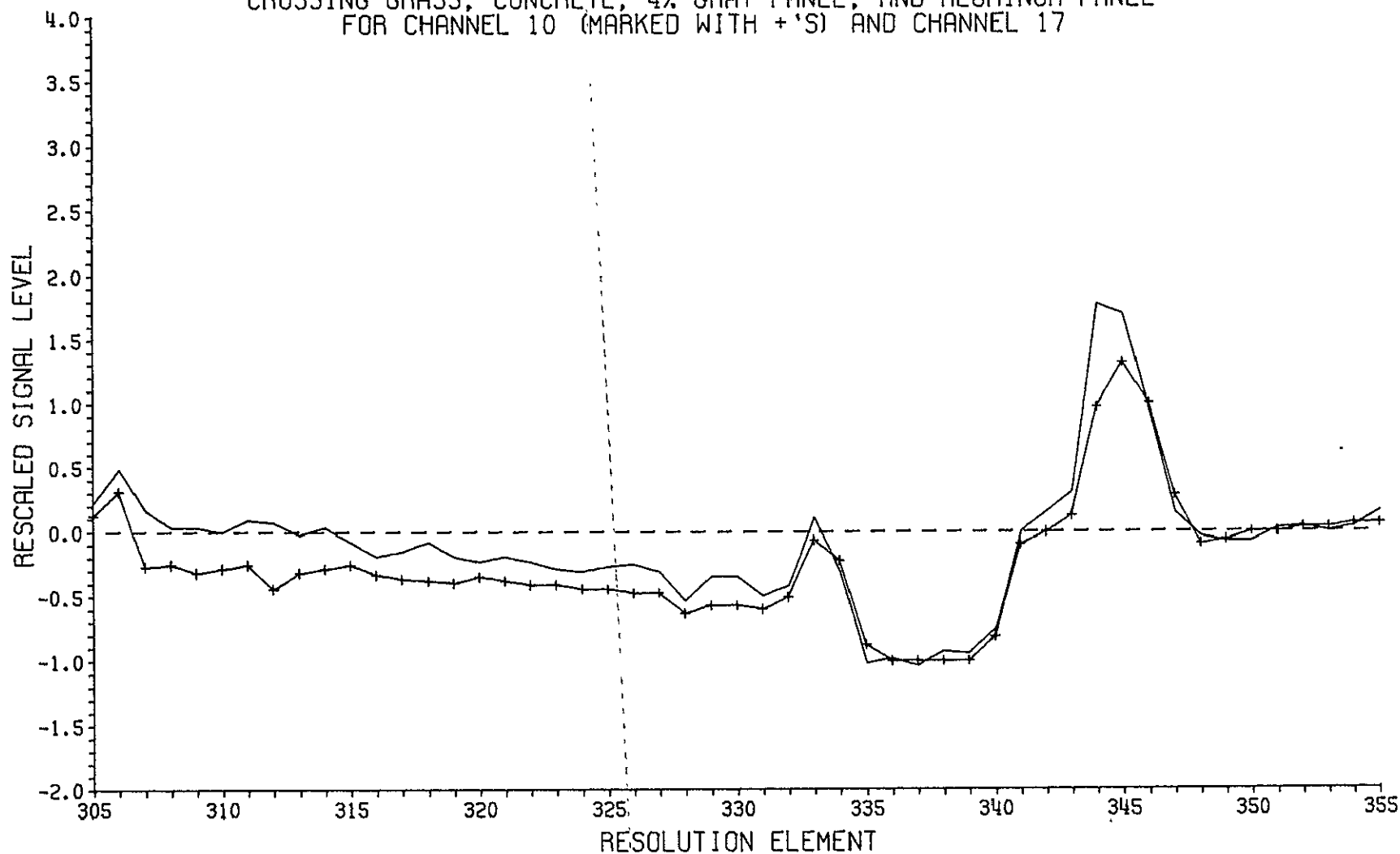
Figure 2.21

Figure 2.22

MSS156-72-C, F3 L2 A7 (CLEAR) 3.4K, PANELS, ETC, ON RAMP (R6/15/72)
06/04/72 16:17:54.6, RADAR ALT 03380 FT, TRUE HEADING 179.4°, DRIFT +04.3°
V/H=0.0887 LOW TEMP=+10.8°C $\Delta T=36.7^{\circ}\text{C}$ FILTER SELECT=1 7.9584SEC/ELEMENT
SEGMENT 0 OF 1
CHANNEL 10: CAL 2, SCALE= 1X, OFFSET=1 CHANNEL 17: CAL 1, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:32:55 SEP 20, 1972 *
(DRAWPLOT, VERSION 1.0, P.F. LAMBECK)
PLOT LINE 1364, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
FOR CHANNEL 10 (MARKED WITH +'S) AND CHANNEL 17



HSS156-72-C, F3 L2 R7 (CLEAR) 3.4K. PANELS, ETC, ON RAMP (R6/15/72)
06/04/72 16:17:54.6. RADAR ALT 03390 FT. TRUE HEADING 178.4°. DRIFT +04.3°
V/H=0.0887 LOW TEMP=-10.9°C $\Delta T=36.7^\circ\text{C}$ FILTER SELECT=1 7.858 $\mu\text{SEC/ELEMENT}$
SEGMENT 0 OF 1
CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 21: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:40:12 SEP 20, 1972 *
(DRAWPLOT, VERSION 1.0, P.F. LAMBECK)
PLOT LINE 1364, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
FOR CHANNEL 10 (MARKED WITH + 'S) AND CHANNEL 21

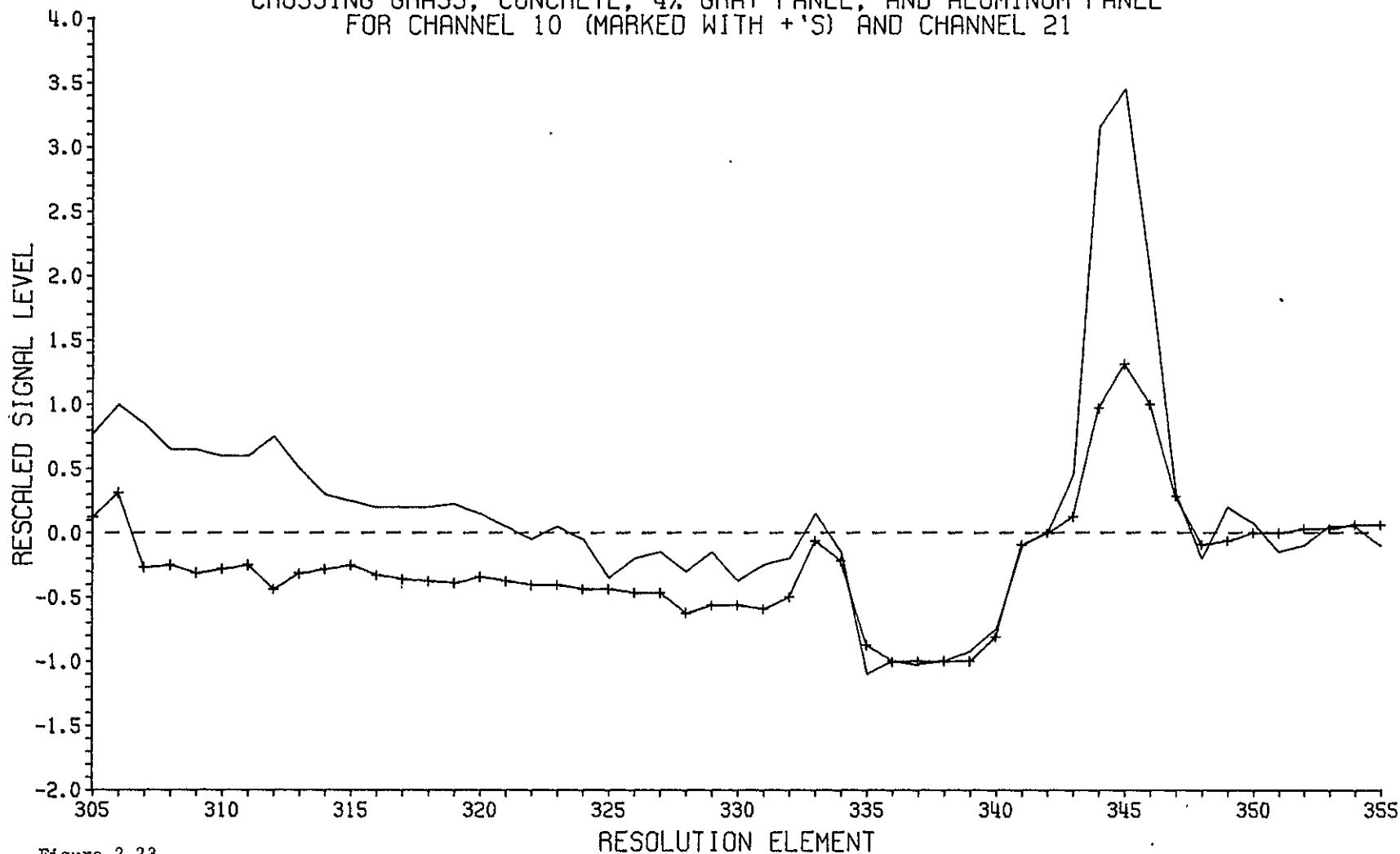


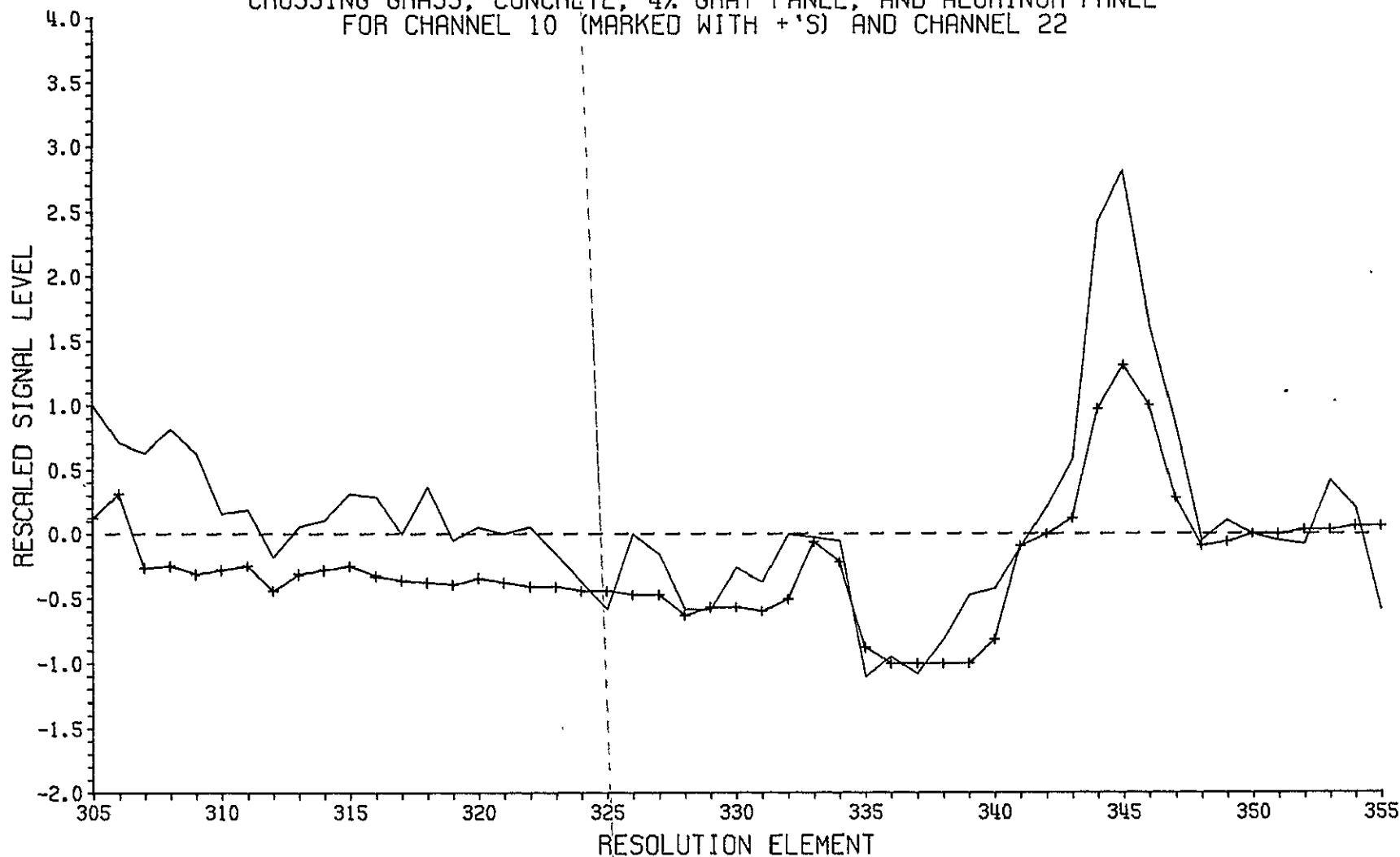
Figure 2.23

Figure 2.24

MSS156-72-C, F3 L2 A7 (CLEAR) 3.4K, PANELS, ETC. ON RAMP (06/15/72)
06/04/72 16:17:54.6, RADAR ALT 03380 FT, TRUE HEADING 179.4°, DRAFT 04.3°
V/H=0.088? LOW TEMP=+10.9°C ΔT=36.7°C FILTER SELECT=1 7.958μSEC/ELEMENT
SEGMENT 0 OF 1
CHANNEL 10: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 22: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:41:56 SEP 20, 1972 *
(DRAWPLOT, VERSION 1.0, P.F. LAMBECK)
PLOT LINE 1364, ELEMENTS 305-355

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT
CROSSING GRASS, CONCRETE, 4% GRAY PANEL, AND ALUMINUM PANEL
FOR CHANNEL 10 (MARKED WITH '+'S) AND CHANNEL 22



HSS146-72-83, HOBBY PVT, KNIFE EDGE (R9/21/72)

V/M=0.1887 LOW TEMP=-24.8°C ΔT = 8.1°C FILTER SELECT=1 3.517 μ SEC/ELEMENT

SEGMENT 0 OF 1

CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1 CHANNEL 8: CAL 2, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 14:08:27 OCT 5, 1972 *
(GRAMPLOT, VERSION 1.0, P.F. LANBECK)
PLOT LINE 18400, ELEMENTS 335-385

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT CROSSING KNIFE EDGE
FOR CHANNEL 9 (MARKED WITH '+'S) AND CHANNEL 2

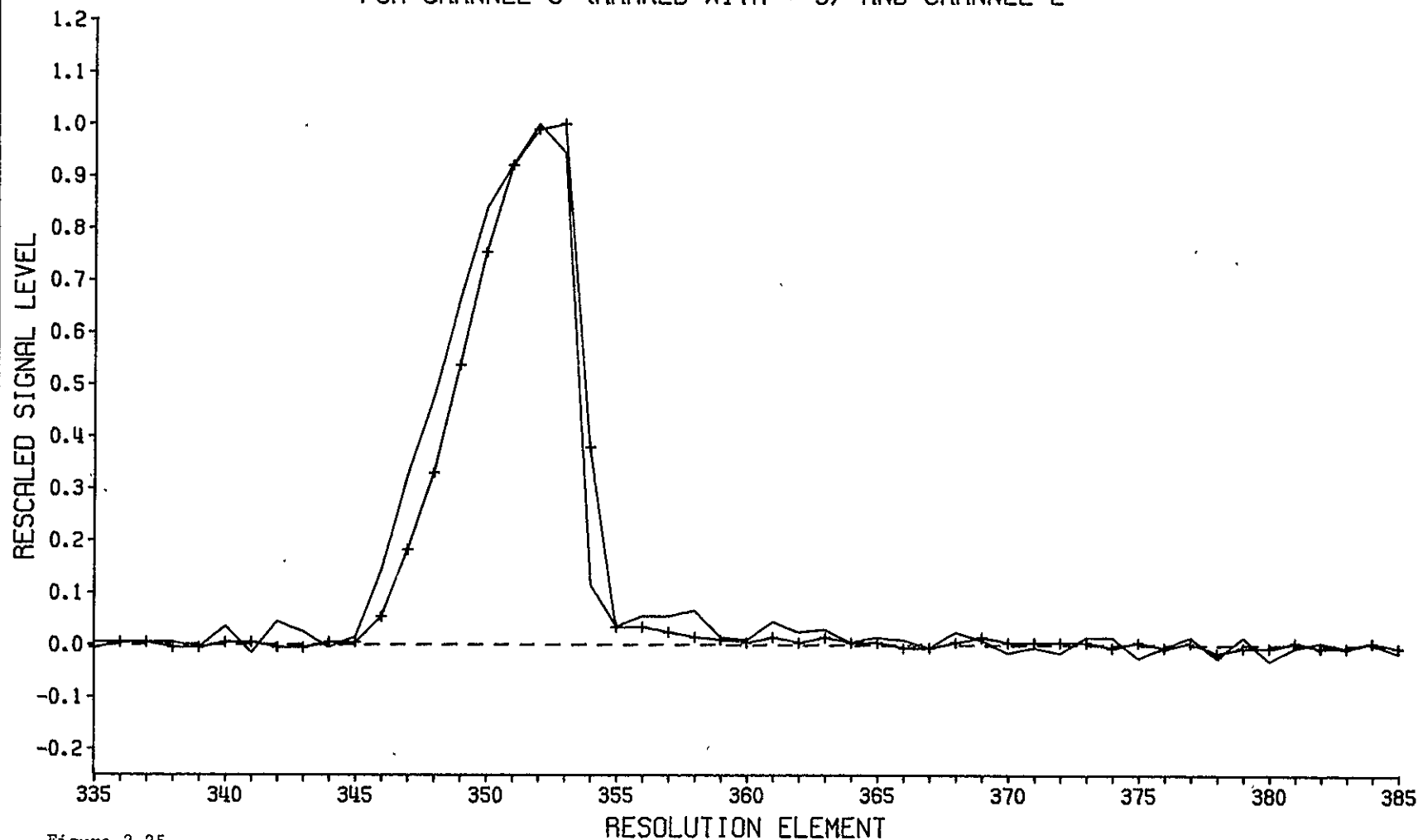


Figure 2.25

Figure 2.26

HSS146-72-89, HOBBY PVT, KNIFE EDGE (R9/21/72)

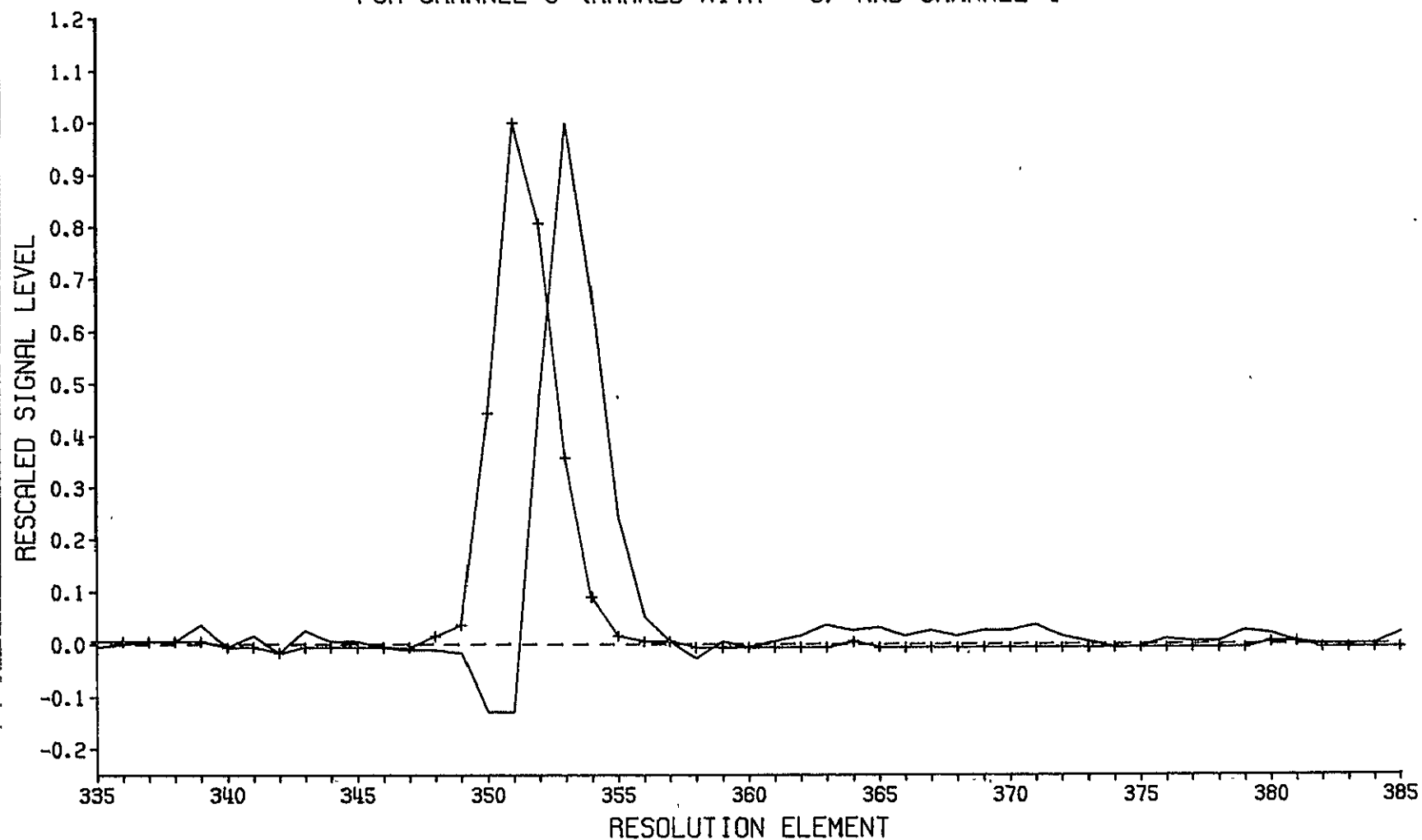
V/H=0.1897 LOW TEMP=-24.8°C $\Delta T=8.0^{\circ}\text{C}$ FILTER SELECT=1 3.517/SEC/ELEMENT

SEGMENT 0 OF 1

CHANNEL 4: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 9: CAL 2, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 14:23:54 OCT 5, 1972 *
(GRAPHLOT, VERSION 1.0, P.F. LAMBECK)
PLOT LINE 34000, ELEMENTS 335-385

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT CROSSING KNIFE EDGE
FOR CHANNEL 9 (MARKED WITH +'S) AND CHANNEL 4



HSS146-72-89, HOBBY PYT, KNIFE EDGE (08/21/72)

V/H=0.1897 LOW TEMP=-24.0°C $\Delta T=9.0^\circ\text{C}$ FILTER SELECT=1 3.5174 SEC/ELEMENT

SEGMENT 0 OF 1

CHANNEL 5: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 9: CAL 2, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 14:24:19 OCT 5, 1972 *

GRAPHLOT, VERSION 1.0, P.F. LANDECKO

PLOT LINE 34000, ELEMENTS 335-385

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT CROSSING KNIFE EDGE
FOR CHANNEL 9 (MARKED WITH '+'S) AND CHANNEL 5

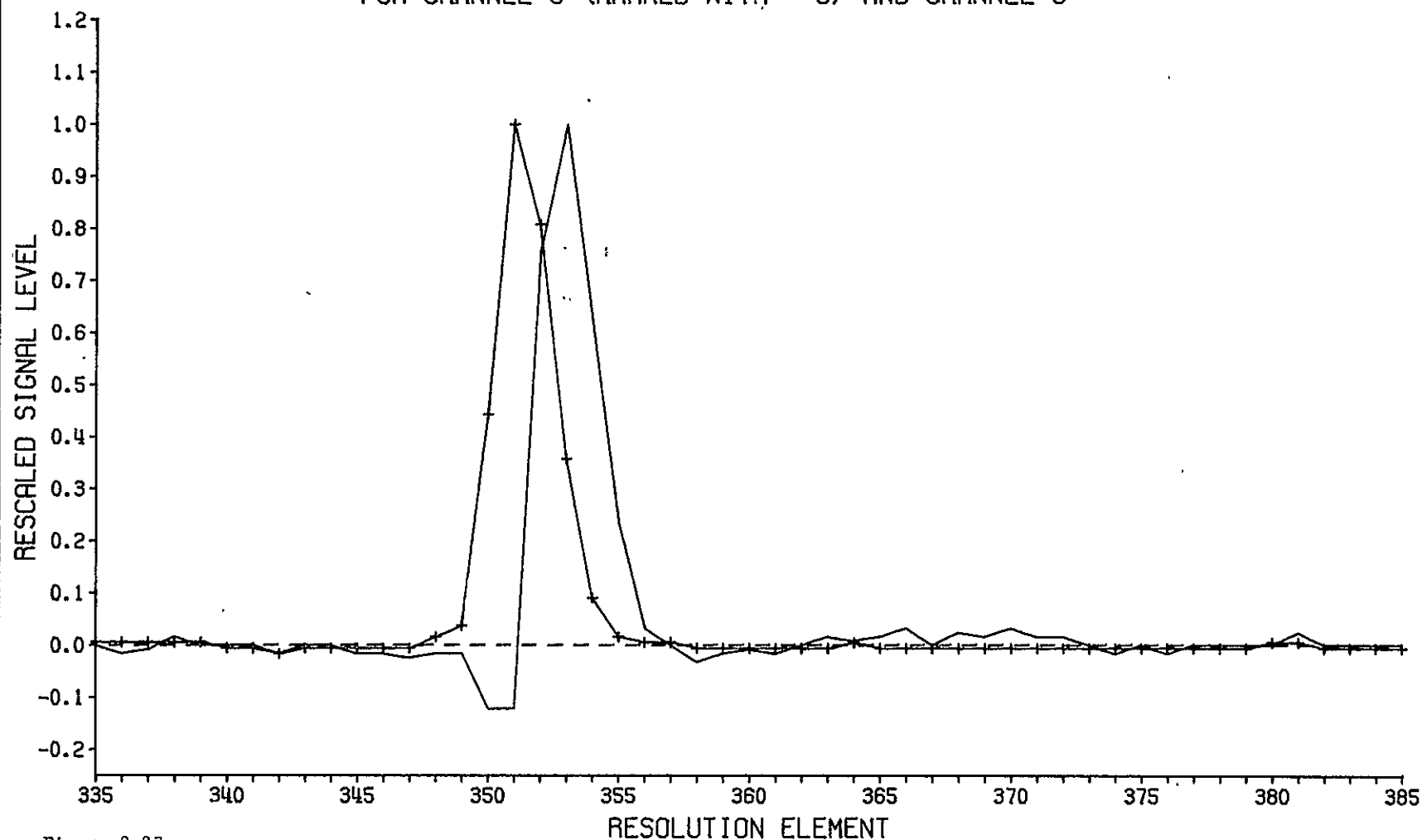


Figure 2.27

Figure 2.28

HSS148-72-83, HOBBY PVT, KNIFE EDGE (08/21/72)

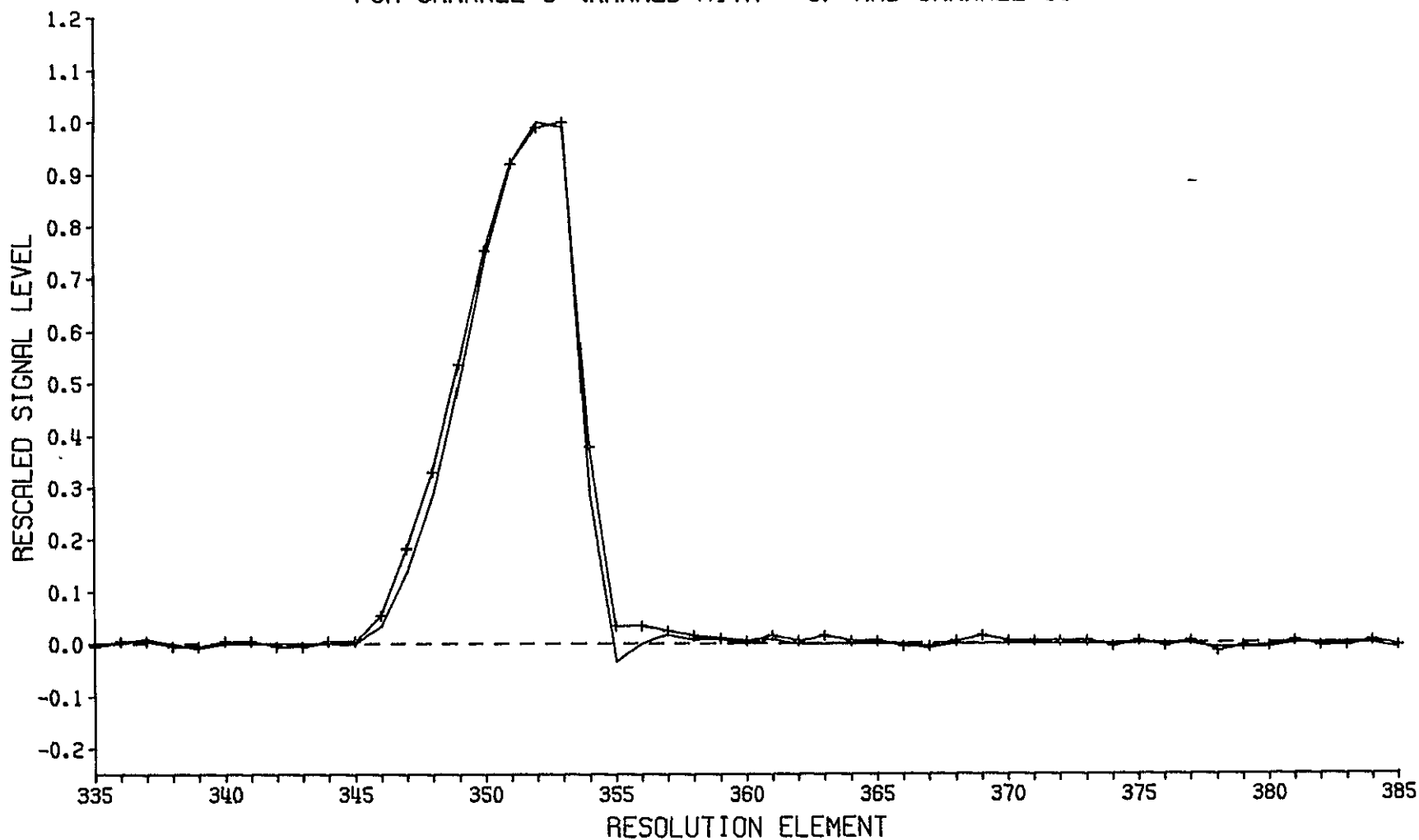
" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 14:11:06 OCT 5, 1972 "
DRAWPLOT, VERSION 1.0, P.F. LAMBECH
PLOT LINE 18400, ELEMENTS 335-385

V/H=0.1067 LOW TEMP=24.0°C $\Delta T = 9.1^\circ\text{C}$ FILTER SELECT=1 3.517 $\mu\text{SEC/ELEMENT}$

SEGMENT 0 OF 1

CHANNEL 9: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 11: CAL 2, SCALE=.25X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT CROSSING KNIFE EDGE
FOR CHANNEL 9 (MARKED WITH '+'S) AND CHANNEL 11



HSS146-72-83, HOBBY PVT, KNIFE EDGE (09/21/72)

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 14:13:10 OCT 5, 1972 *
(GRAMPLOT, VERSION 1.0, P.F. LAMBECK)
PLOT LINE 18400, ELEMENTS 335-385

V/M=0.1897 LOW TEMP=-24.9°C $\Delta T=0.1^{\circ}\text{C}$ FILTER SELECT=1 3.517 $\mu\text{SEC}/\text{ELEMENT}$

SEGMENT 0 OF 1
CHANNEL 9: CAL 2, SCALE=1X, OFFSET=1 CHANNEL 13: CAL 2, SCALE=.25X, OFFSET=1

RESCALED RADIANCE PLOT OF SCAN LINE SEGMENT CROSSING KNIFE EDGE
FOR CHANNEL 9 (MARKED WITH '+'S) AND CHANNEL 13

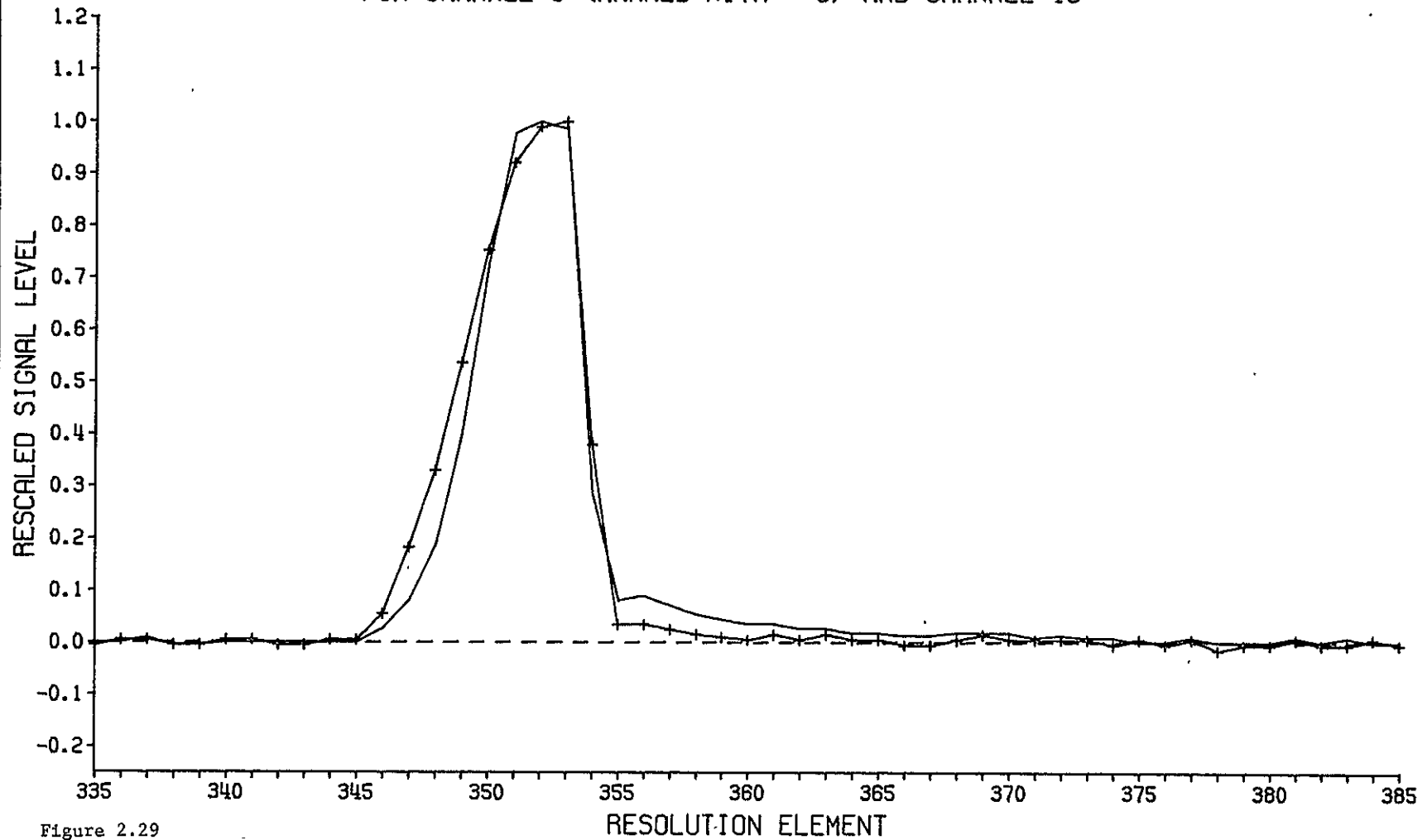


Figure 2.29

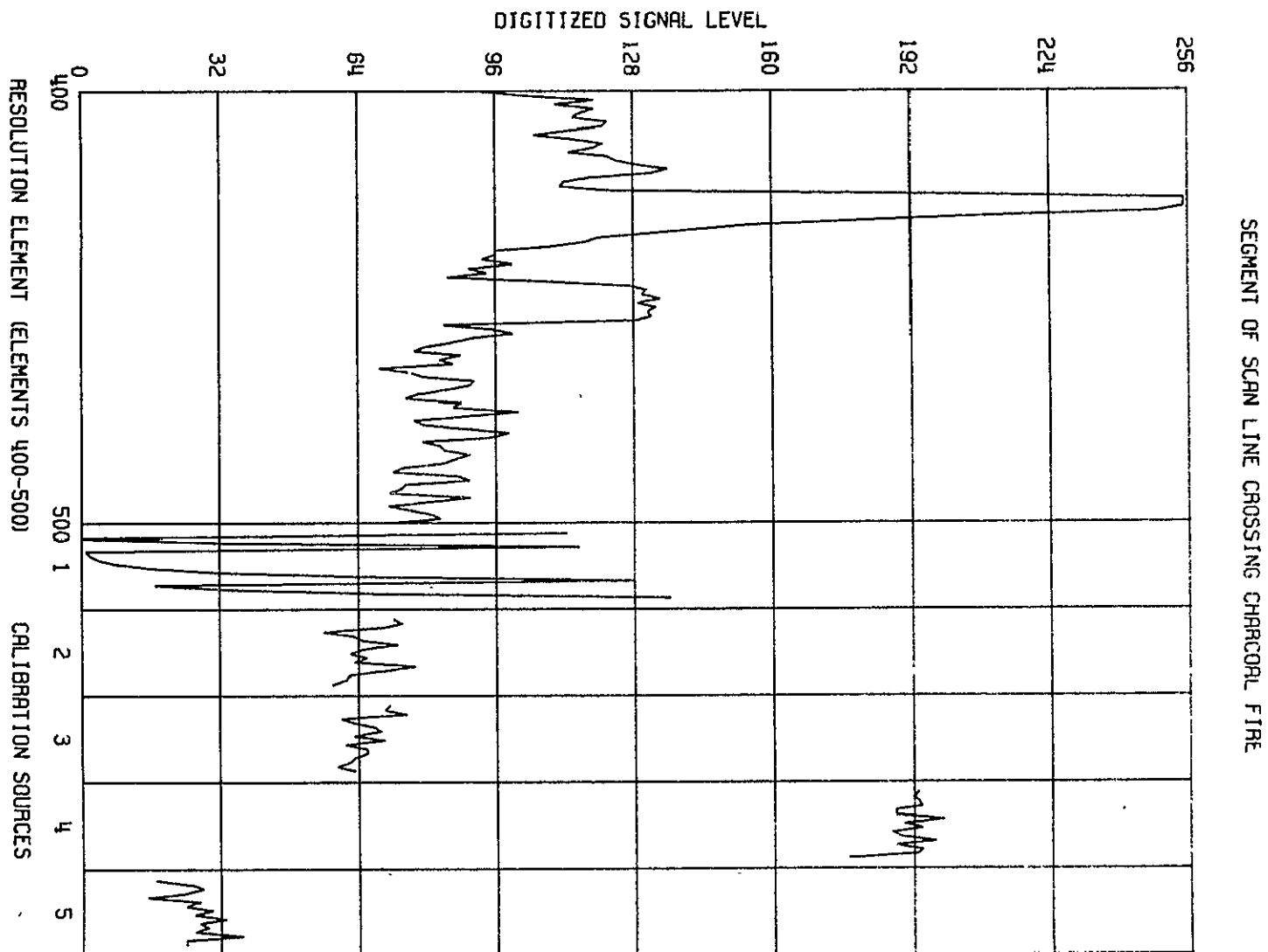
Thermal Response to a Small Charcoal Fire

Figures 3.1-3.4 show examples of thermal response to a 2 foot x 1 foot charcoal fire from an altitude of 3.4 thousand feet. Channels 14 and 15 exhibit a slow exponential recovery from saturation at the high signal level (Figures 3.1 and 3.2). Channel 16 (a water absorption band) shows no response at this altitude, as one would expect (Figure 3.3). Channel 17 (Figure 3.4) typifies the response of the channels 17 through 22, which was good. Data from the Hobby knife edge tests as well as other data indicates that a slow exponential recovery from saturation as shown in channels 14 and 15 is characteristic of most if not all channels of the system.

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 19:35:15 SEP 12, 1972 *
 (LARGE)PLOT, VERSION 2.0, P.F. LAMBECK
 PLOT LINE 2172, ELEMENTS 400-500, AND CAL SOURCES

NSS154-72-B, F2 L2 R7 (OVERCAST) 3.4K, PANELS, ETC. ON RAMP (08/15/72)
 06/02/72 17:24:14.8, RADAR ALT 03400 FT, TRUE HEADING 186.2°, DRIFT -08.0°
 V/H=0.0067 LOW TEMP=+10.0°C ΔT=36.0°C FILTER SELECT=1 7.958μSEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 14: CAL 1, SCALE= 1X , OFFSET=1

Figure 3.1



MSS154-72-B, F2 L2 R7 (OVERCAST) 3.4K, PANELS, ETC. ON RAMP (06/15/72)
 06/02/72 17:24:14.9, RADAR ALT 03400 FT, TRUE HEADING 106.2°, DRIFT -08.0°
 V/H=0.0887 LON TEMP=-10.0°C ΔT=36.0°C FILTER SELECT=1 7.958μSEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 15: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 18:35:15 SEP 12, 1972 *
 LARGE PLOT, VERSION 2.0, P.F. LAMBECKO
 PLOT LINE 2172, ELEMENTS 400-500, AND CAL SOURCES

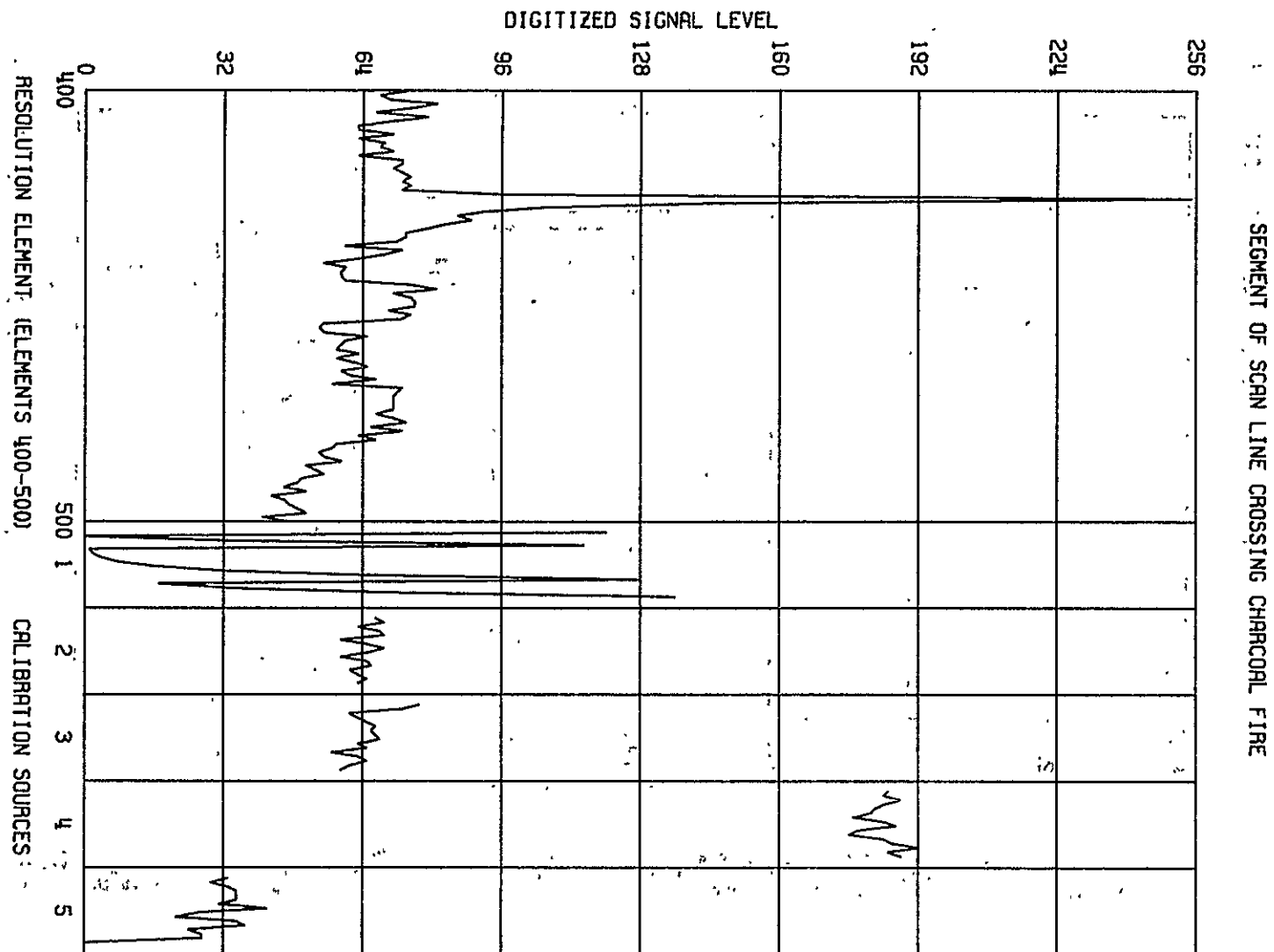
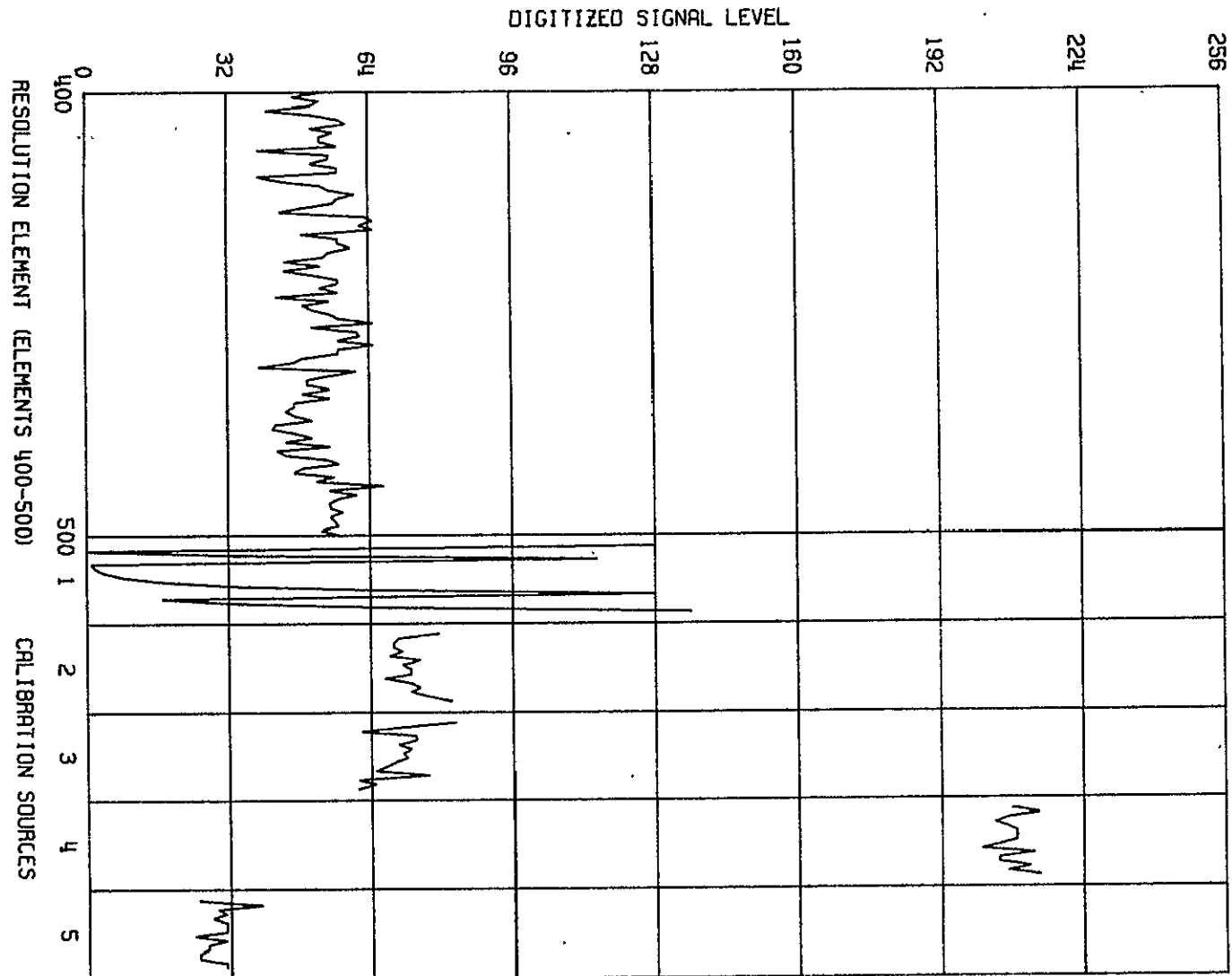


Figure 3.2

SEGMENT OF SCAN LINE CROSSING CHARCOAL FIRE



ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 19:35:15 SEP 12, 1972 *
 LARGEPLLOT, VERSION 2.0, P.F. LAMBECKO
 PLOT LINE 2172, ELEMENTS 400-500, AND CAL SOURCES

NSS154-72-8, F2 L2 A7 (OVERCAST) 3.4K, PANELS, ETC. ON RAMP (06/15/72)
 06/02/72 17:24:14.8, RADAR ALT 03400 FT, TRUE HEADING 186.2°, DRIFT -08.0°
 V/H=0.0887 LOW TEMP=+10.0°C ΔT=36.8°C FILTER SELECT=1 7.958μSEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 16: CAL 1, SCALE= 1X, OFFSET=1

Figure 3.3

MSS154-72-B, F2 L2 A7 (OVERCAST) 3.4K, PANELS, ETC, ON RAMP (08/15/72)
 08/02/72 17:24:14.8, MAGDA ALT 03400 FT, TRUE HEADING 106.2°, DRIFT -06.0°
 V/H-0.0007 LOW TEMP=-10.0°C $\Delta T=36.0^{\circ}\text{C}$ FILTER SELECT=1 7.950-SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 17: CAL 1, SCALE= 1X , OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 18:35:15 SEP 12, 1972 *
 CLARGEPL0T, VERSION 2.0, P.F. LAMBECKO
 PLOT LINE 2172, ELEMENTS 400-500, AND CAL SOURCES

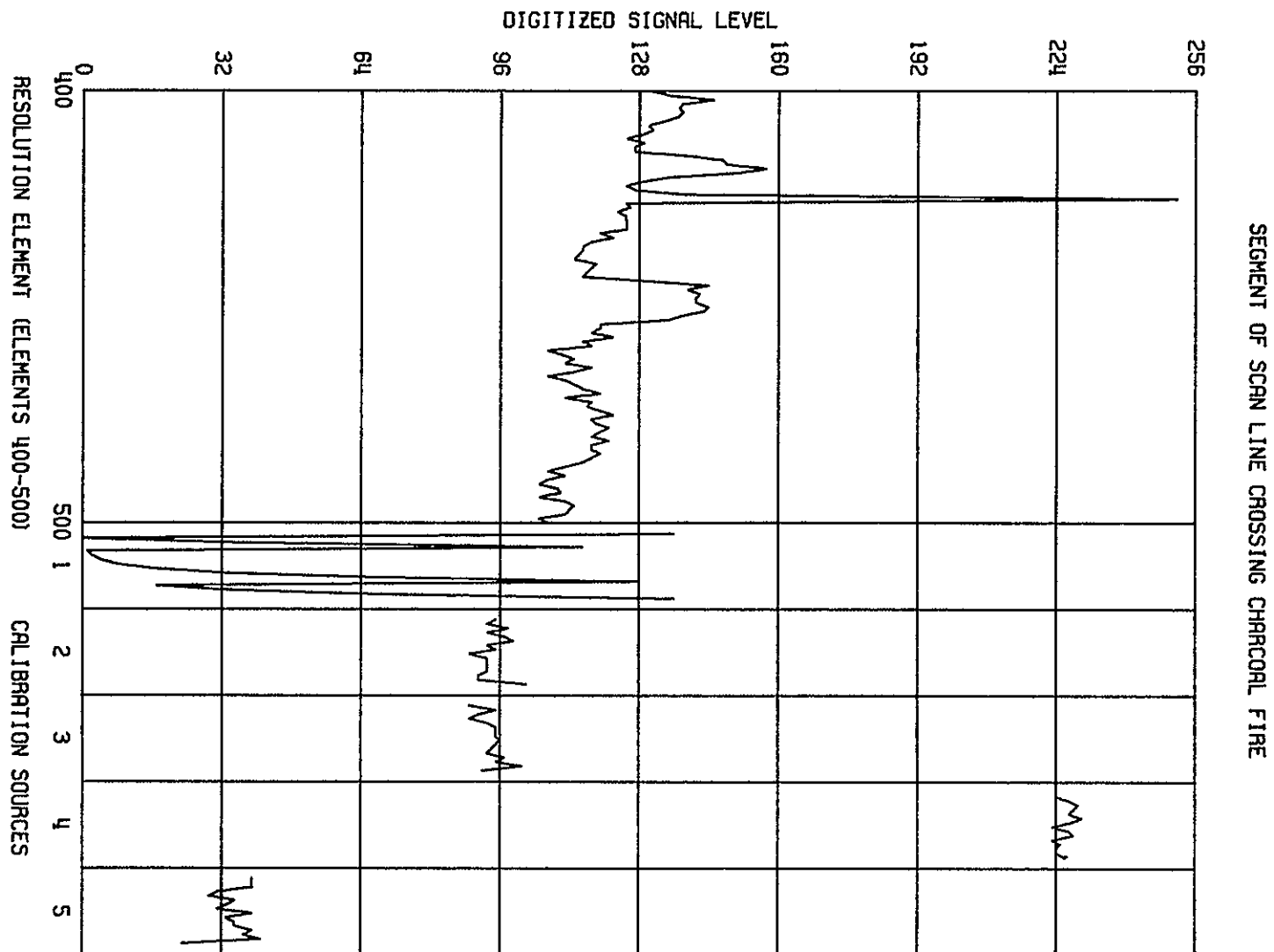


Figure 3.4

Scan Line Registration

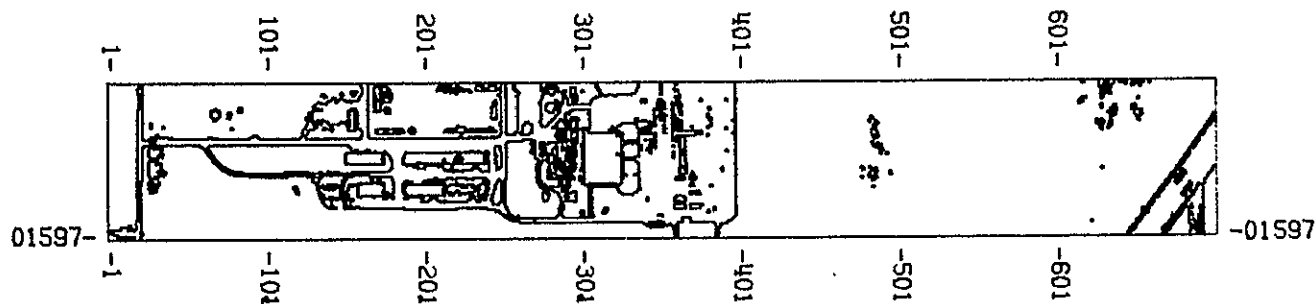
Inspection of the DAS film edits we received revealed a few instances where successive scan lines appeared to waver in and out of registration by plus or minus 1 resolution element. In Figure 4.2, edit 9, one can see jagged edges on the large blue building rooftop near the ramp while in edit 10 such jagged edges are not evident. Steplike variations in edges might be expected due to the effect of digitization, but oscillating variations such as those in edit 9 would be unlikely. Figure 4.1 shows two contour plots of tape edits we obtained which correspond to the two DAS film edits of Figure 4.2. The stairstep edges visible on some of the roads are due to the effects of digitization, which is not smoothed in these plots. Note that while the plot for run 9 (airspeed 270 knots and virtually no drift) looks very clean, the plot for run 8 (airspeed 160 knots with noticeable drift) shows jagged edges very much like those in DAS edit 9. Close inspection of the contour plot for run 8 (plotted to a larger scale in Figure 4.3) indicates that the variations in registration of the scan lines can be identified across almost the entire width of the scan (note variations in edges of road at resolution element 15 and similar variations in edges of building rooftop near elements 292 and 315; especially near scan line 1722 - Figure 4.3). Listings obtained for our tape edits indicate that channel swapping did not occur during this edit, hence these registration oscillations could be due to variations in the timing of the start of each scan line. This phenomenon may be related to roll gyro problems.

Figure 4.1

NSS156-72-C, F3 L2 R8 (CLEAR) 3.4K, PANELS, ETC, ON RAMP (06/15/72)
 06/04/72 18:33:15.7, RADAR ALT 03380 FT, TRUE HEADING 178.9°, DRAFT +00.9°
 V/H=0.1307 LOW TEMP=+11.3°C $\Delta T=36.6^\circ\text{C}$ FILTER SELECT=1 4.716/SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1

« ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 19:58:44 NOV 6, 1972 »
 (CONTOUR, VERSION 2.0, P.F. LAMBECK)
 CONTOUR AT LEVELS 96,180 - 1 LINE X 1 ELEMENT AVERAGING
 PLOT ALL LINES, ALL ELEMENTS

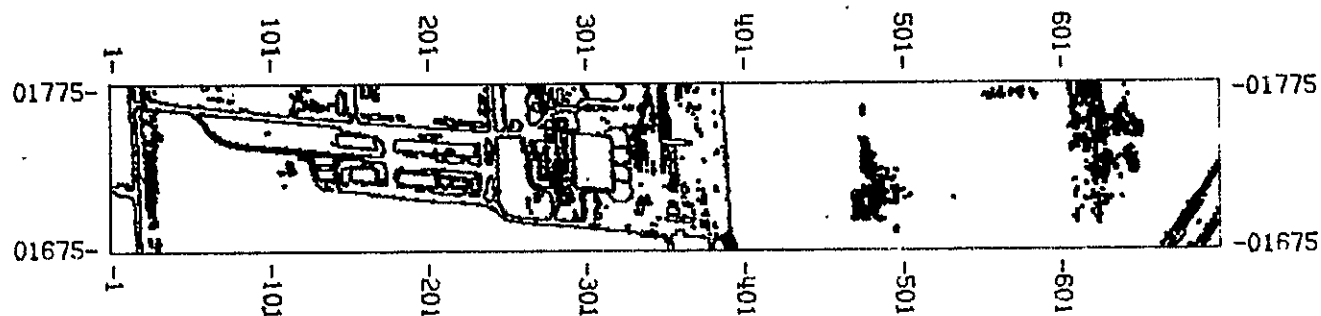
OUTLINES OF BUILDINGS, PANELS, ROADS, ETC.



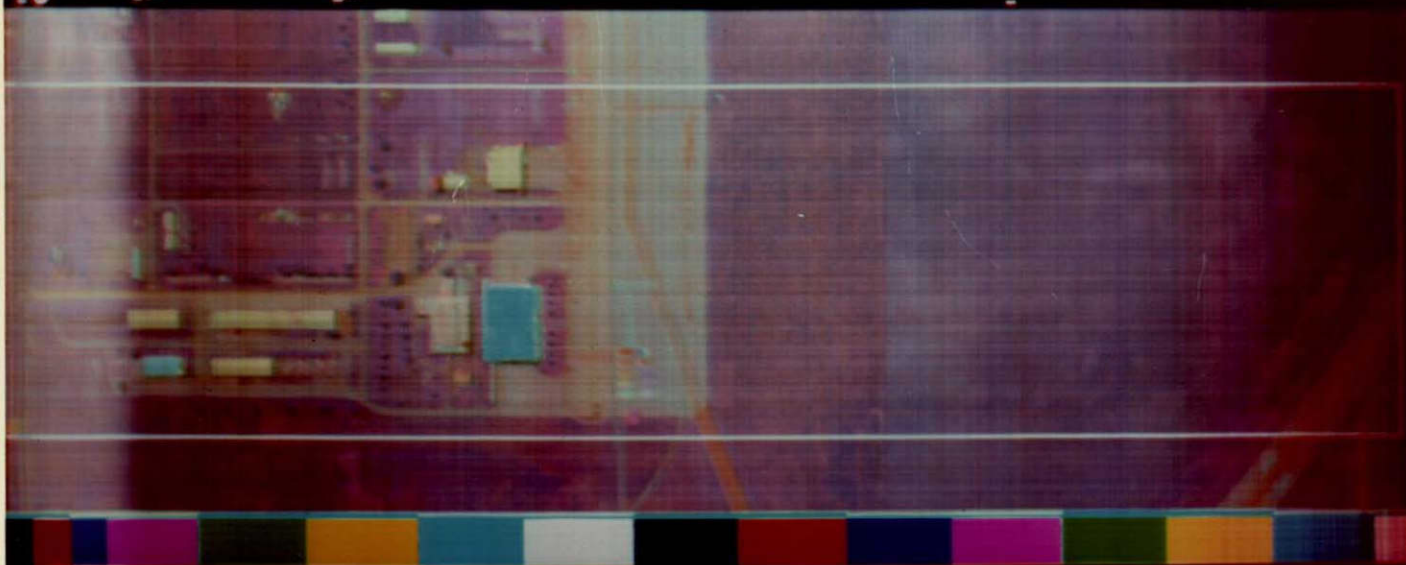
NSS156-72-C, F3 L2 R8 (CLEAR) 3.4K, PANELS, ETC, ON RAMP (06/15/72)
 V/H=0.0887 LOW TEMP=+10.9°C $\Delta T=36.7^\circ\text{C}$ FILTER SELECT=1 7.858/SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 2: CAL 2, SCALE=.25X, OFFSET=1

« ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 19:53:00 NOV 6, 1972 »
 (CONTOUR, VERSION 2.0, P.F. LAMBECK)
 CONTOUR AT LEVELS 25,42 - 1 LINE X 1 ELEMENT AVERAGING
 PLOT ALL LINES, ALL ELEMENTS

OUTLINES OF BUILDINGS, PANELS, ROADS, ETC.



10



09

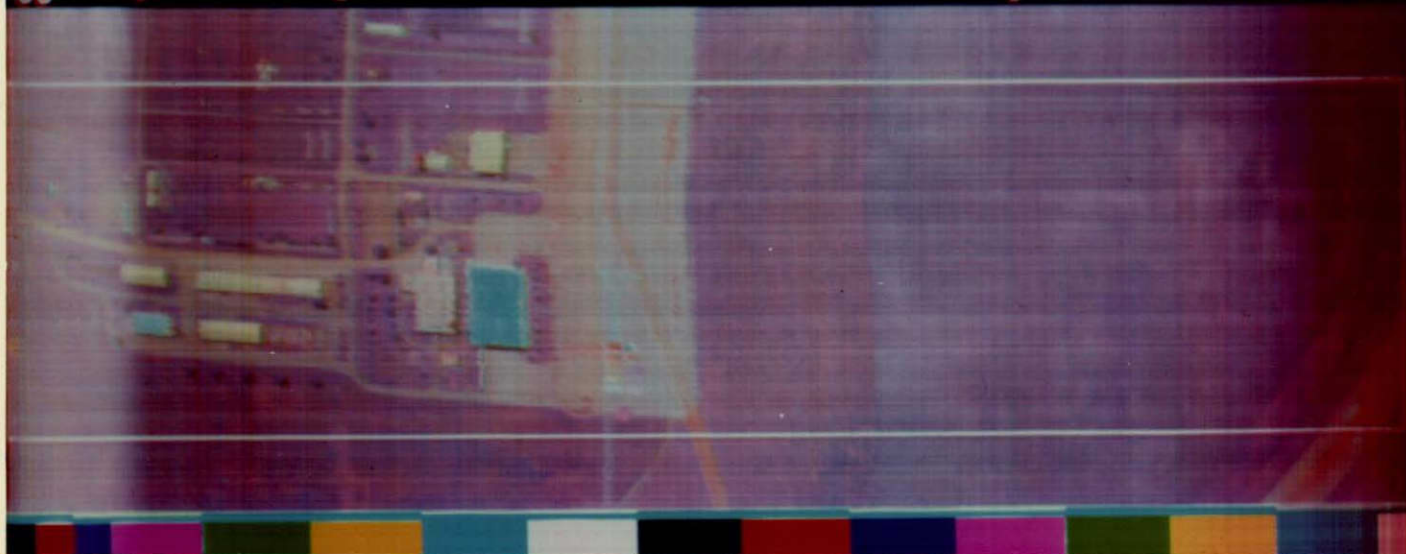


Figure 4.2
DAS Film, Runs 8 & 9
3.4K ft. 6/4/72
19-R 2-G 11-B

HSS158-72-C, F3 L2 R8 (CLEAR) 3.4K, PANELS, ETC. ON RAMP (R6/15/72)
 V/H=0.0007 LON TEMP=+10.9°C $\Delta T=36.7^{\circ}\text{C}$ FILTER SELECT=1 7.858 $\mu\text{SEC/ELEMENT}$
 SEGMENT 1 OF 1
 CHANNEL 2: CAL 2, SCALE=.25X, OFFSET=1

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 17:30:58 NOV 7, 1972 "
 (CONTOUR, VERSION 2.0, P.F. LANBECK)
 CONTOUR AT LEVELS 25.42 - 1 LINE X 1 ELEMENT AVERAGING
 PLOT ALL LINES, ELEMENTS 1-401

OUTLINES OF BUILDINGS, PANELS, ROADS, ETC.

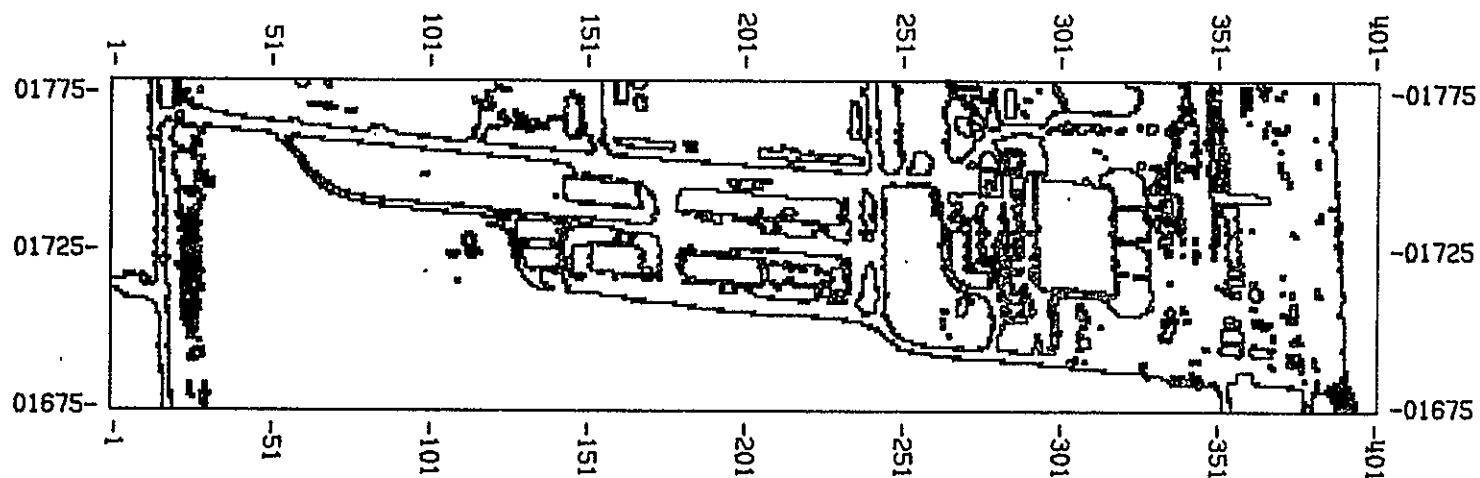


Figure 4.3

Response vs. Scan Angle

Dirt, smudges, etc. on the optical surfaces of the scanner can cause variations in response from one portion of the scan to another. Data from run 23, flying south to north, was compared to data from run 24, which immediately followed run 23 and flew north to south, to determine whether any scan angle related response variations could be detected. Some small amounts of signal drift were apparent (see Section 8), but no scan angle related variations in response were evident in any channel, indicating that any scan angle anomalies were no worse than 5 percent. Figures 5.1 through 5.6 reproduce scan lines from runs 23 and 24, crossing the 4 percent gray panel and the aluminum panel, which were studied for scan angle variations in channels 2, 8 and 19.

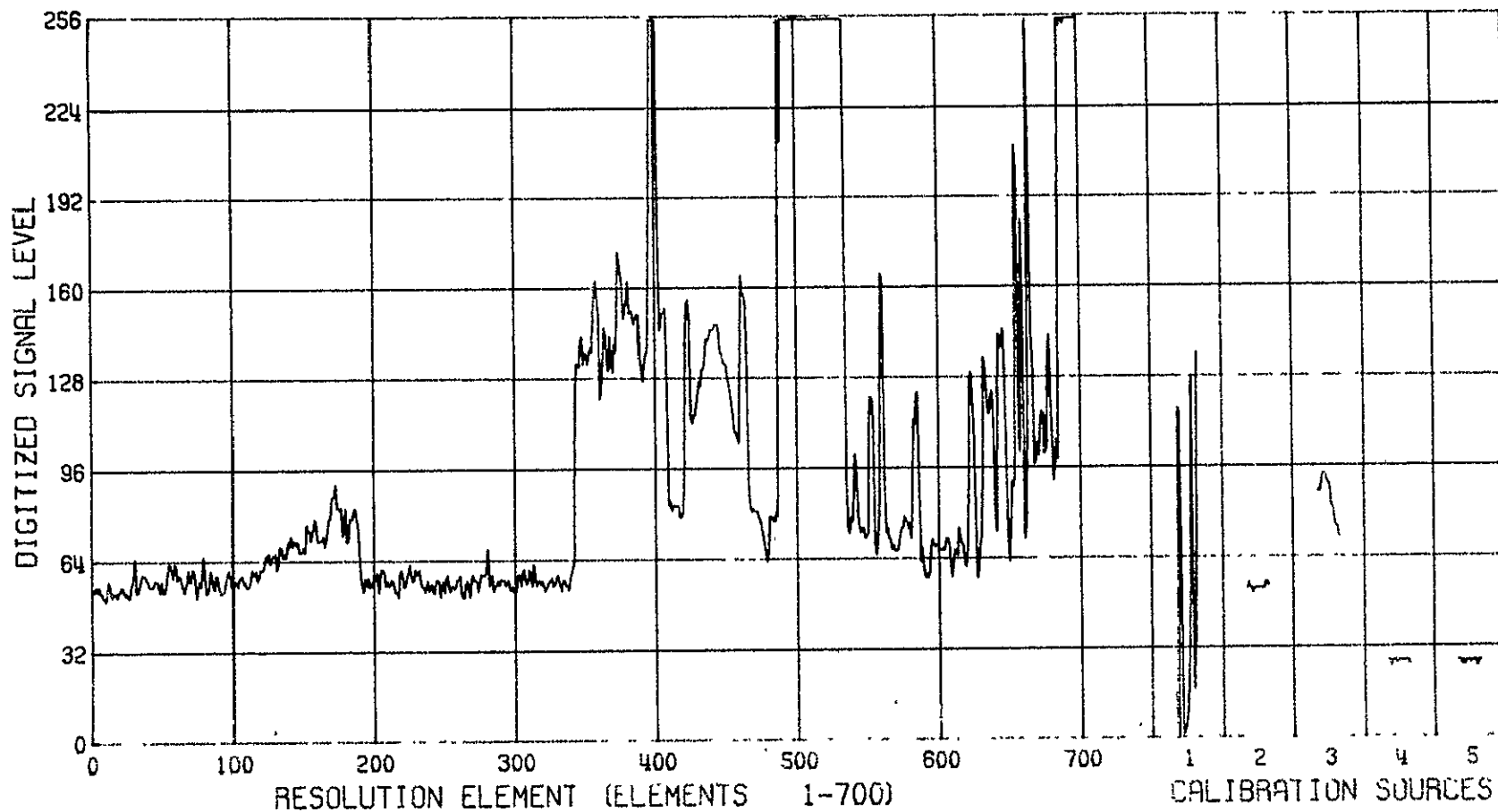
Figure 5.1

NSS158-72-0, F3 L2 R23 (CLEAN) 1.7K, PANELS, ETC. ON RAMP (06/15/72)
 06/04/72 18:44:54.0, RADAR ALT 01610 FT, TRUE HEADING 357.9°
 V/T=0.1687 LOW TEMP=+11.1°C $\Delta T=38.5^{\circ}\text{C}$ FILTER SELECT=1 3.979SEC/ELEMENT

UNIVERSITY OF MICHIGAN 1ST IROL 16:52:03 JUL 5, 1972 = SEGMENT 1 OF 1
 (SMALLPLOT, VERSION 2.0, P.F. LANBECK)
 PLOT LINE 7547, ALL ELEMENTS, AND CAL SOURCES

CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1

SCAN LINE CROSSING RAMP, 4% GRAY PANEL, AND ALUMINUM PANEL



MSS156-72-0, F3 L2 R24 (CLEAR) 1.7K, PANELS, ETC. ON RAMP (R6/15/72)

V/H=0.1687 LOW TEMP=-11.0°C $\Delta T=38.4^{\circ}\text{C}$ FILTER SELECT=1 3.978 $\mu\text{SEC/ELEMENT}$

CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1

* UNIVERSITY OF MICHIGAN 1ST JROL 17:07:19 JUL 5, 1972 * SEGMENT 1 OF 1
(SMALLPLOT, VERSION 2.0, P.F. LANDECK)
PLOT LINE 5879, ALL ELEMENTS, AND CAL SOURCES

SCAN LINE CROSSING RAMP, 4% GRAY PANEL, AND ALUMINUM PANEL

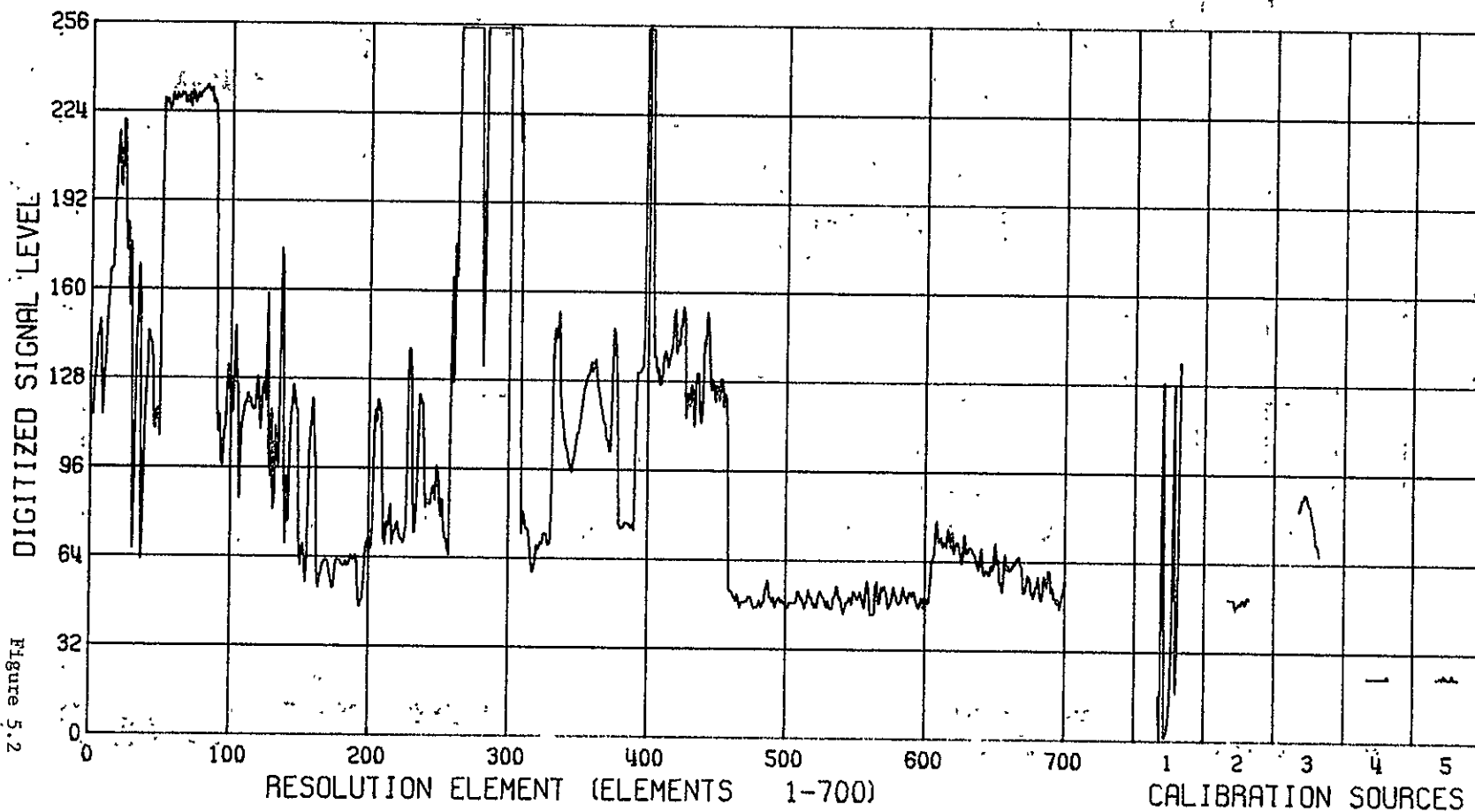


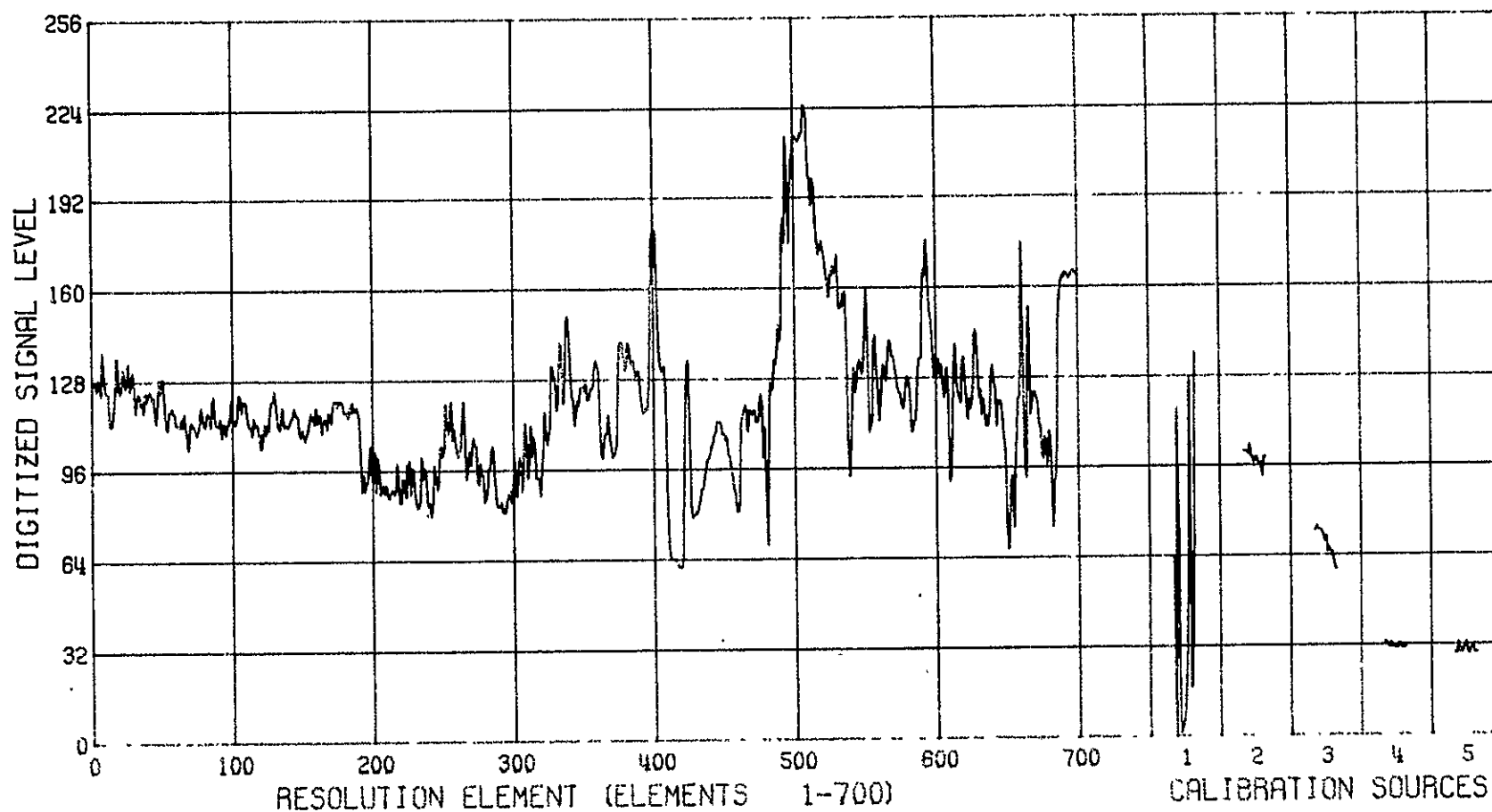
Figure 5.2

Figure 5.3

HSS156-72-0, F3 L2 R29 (CLEAN) 1.7K, PANELS, ETC. ON RAMP (A8/15/72)
 08/04/72 18:44:54.0, RADOM ALT 01610 FT, TRUE HEADING 357.8°
 V/H=0.1687 LOW TEMP=-11.1°C $\Delta T=38.5^{\circ}\text{C}$ FILTER SELECT=1 3.979/SEC/ELEMENT
 CHANNEL 8: CAL 2, SCALE=1X, OFFSET=1

* UNIVERSITY OF MICHIGAN 1ST INCL 18:52:03 JUL 5, 1972 * SEGMENT 1 OF 1
 (SMALLPLOT, VERSION 2.0, P.F. LAMBECK)
 PLOT LINE 7547, ALL ELEMENTS, AND CAL SOURCES

SCAN LINE CROSSING RAMP, 4% GRAY PANEL, AND ALUMINUM PANEL



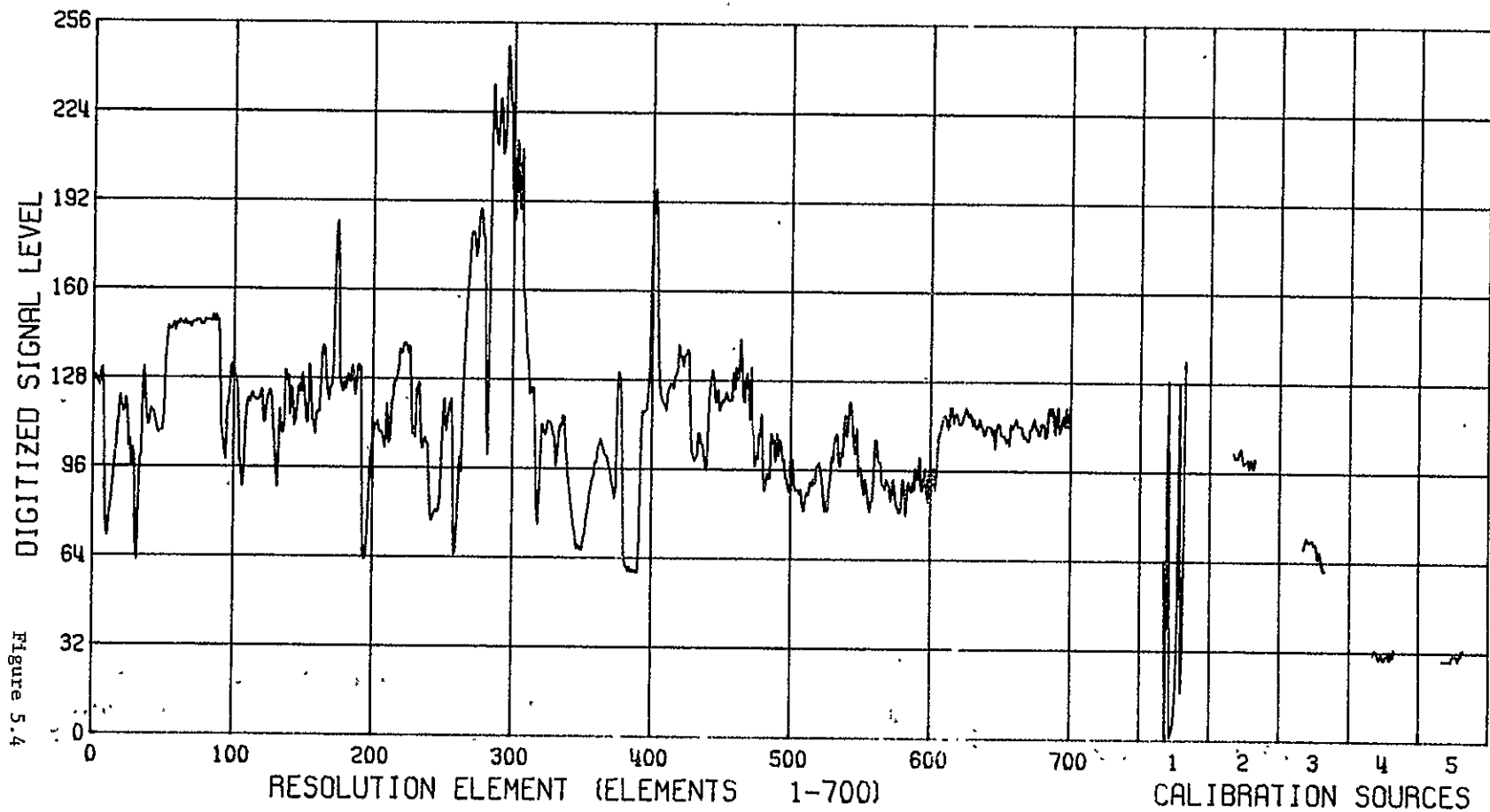
MSS158-72-0, F3 L2 R24 (CLEAR) 1.7K, PANELS, ETC, ON RAMP (18/15/72)

V/H=0.1607 LOW TEMP=+11.0°C $\Delta T=38.4^{\circ}\text{C}$ FILTER SELECT=1 3.979 $\mu\text{SEC/ELEMENT}$

CHANNEL 8: CAL 2. SCALE= 1X , OFFSET=1

* UNIVERSITY OF MICHIGAN 1ST IROL 17:07:19 JUL 5, 1972 * SEGMENT 1 OF 1
(SMALLPLOT, VERSION 2.0, P.F. LANBECK)
PLOT LINE 5879, ALL ELEMENTS, AND CAL SOURCES

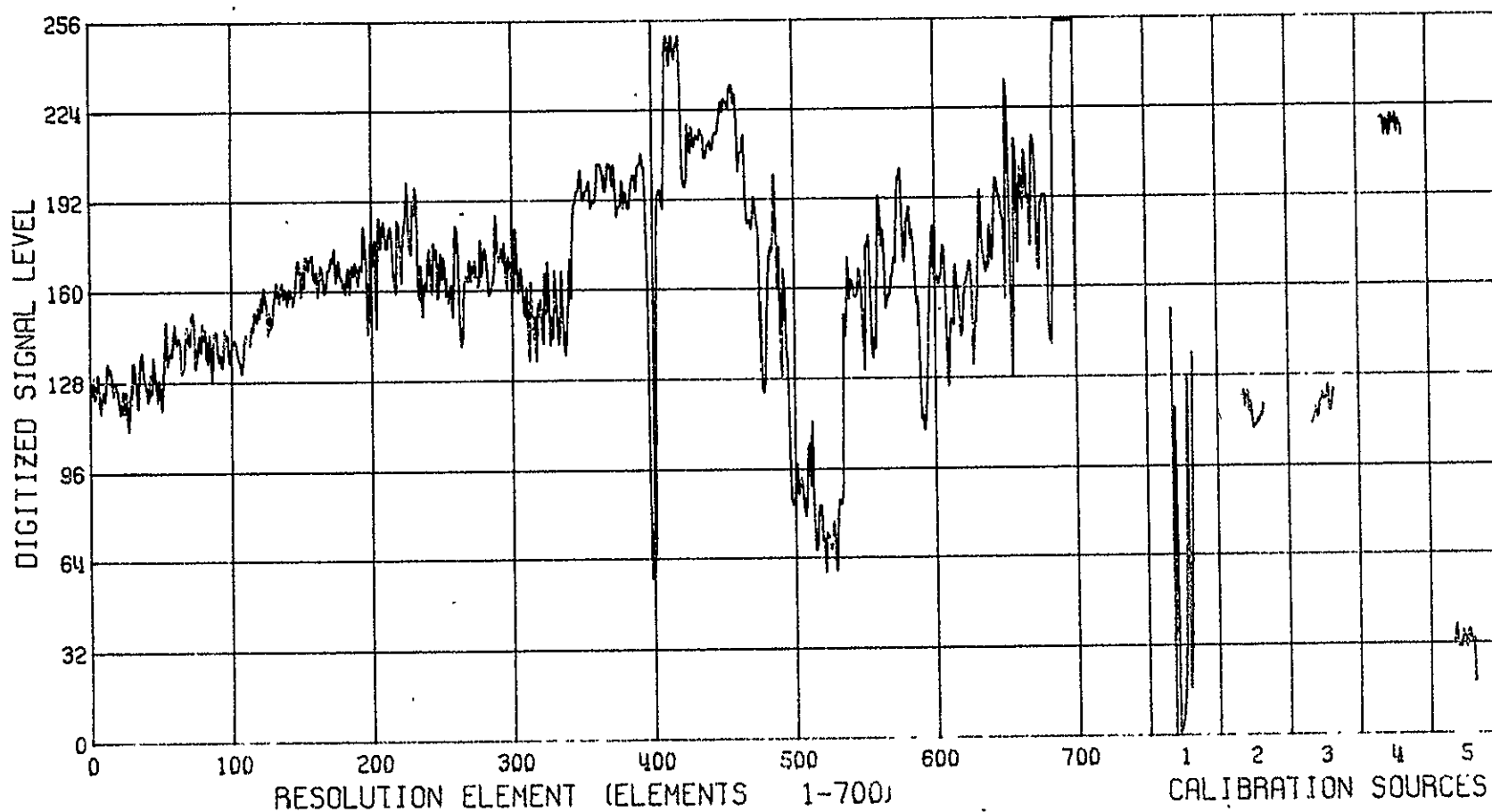
SCAN LINE CROSSING RAMP, 4% GRAY PANEL, AND ALUMINUM PANEL



HSS156-72-0, F3 L2 A23 (CLEAR) 1.7K, PANELS, ETC. ON RAMP 06/15/72
 06/04/72 10:44:54.0. RADAR ALT 01810 FT. TRUE HEADING 357.9°
 V/H=0.1687 LOW TEMP=-11.1°C $\Delta T=36.5^{\circ}\text{C}$ FILTER SELECT=1 3.978 $\mu\text{SEC/ELEMENT}$
 CHANNEL 19: CAL 1. SCALE= 1X . OFFSET=1

* UNIVERSITY OF MICHIGAN 1ST IADL 16:52:03 JUL 5, 1972 * SEGMENT 1 OF 1
 (SMALLPLOT, VERSION 2.0, P.E. LANBECK)
 PLOT LINE 7547. ALL ELEMENTS, AND CAL SOURCES

SCAN LINE CROSSING RAMP, 4% GRAY PANEL, AND ALUMINUM PANEL



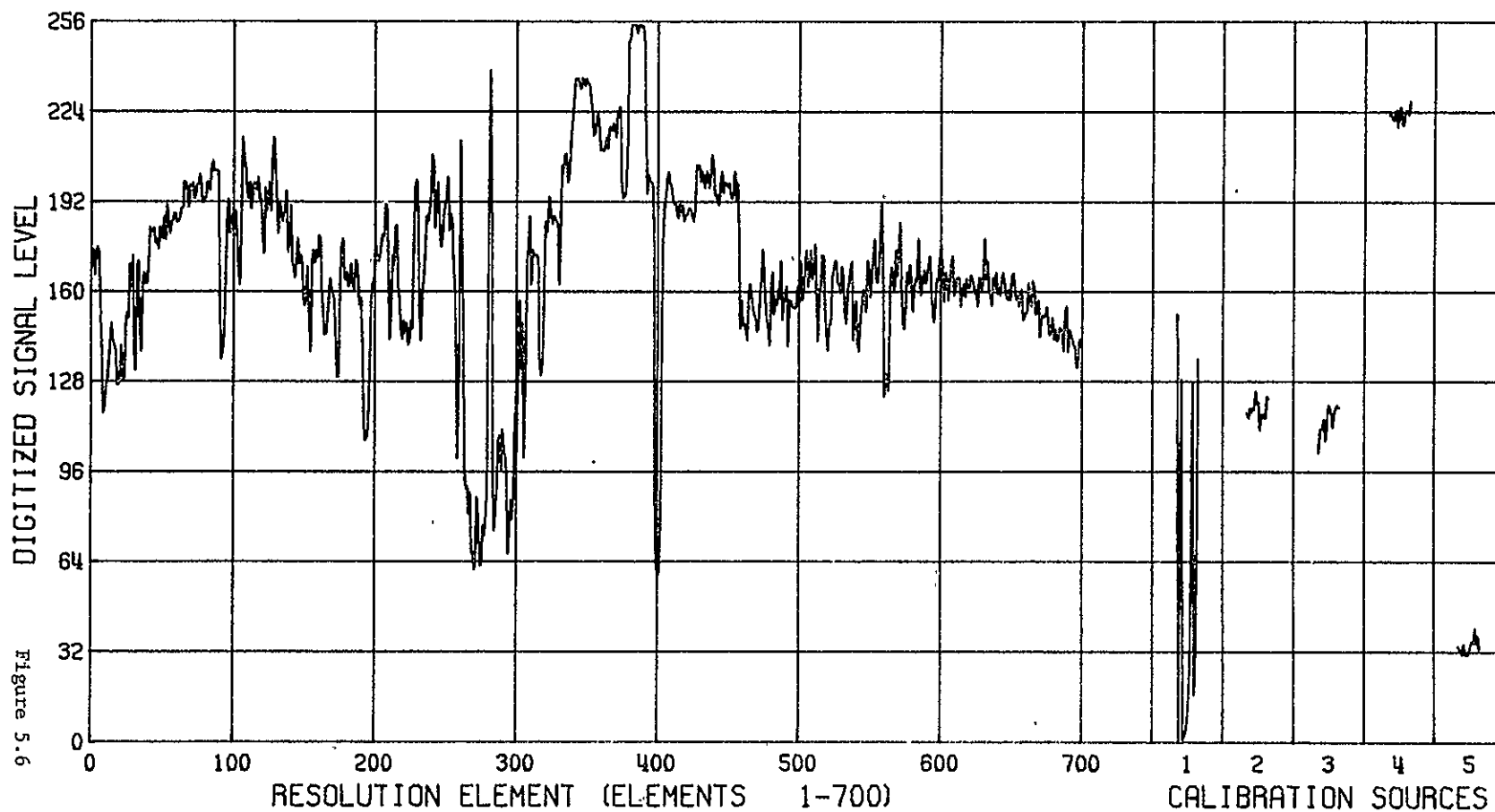
MSS158-72-0, F3 L2 R24 (CLEAR) 1.7K. PANELS, ETC. ON RAMP (R8/15/72)

V/I=0.1682 LOW TEMP=+11.0°C ΔT=36.4°C FILTER SELECT=1 3.979SEC/ELEMENT

CHANNEL 19: CAL 1. SCALE= 1X . OFFSET=1

* UNIVERSITY OF MICHIGAN IST IROL 17:07:19 JUL 5, 1972 * SEGMENT 1 OF 1
SMALLPLOT, VERSION 2.0, P.F. LANDECKO
PLOT LINE 5679, ALL ELEMENTS, AND CAL SOURCES

SCAN LINE CROSSING RAMP, 4% GRAY PANEL, AND ALUMINUM PANEL



Noise, Digital Hang-ups, etc.

Figure 6.2 is a print made from an RC-8 photograph taken over Belleville Lake during run 12 on 2 June (overcast day). This lake will be used as an approximate uniform signal source to evaluate noise characteristics. Note the clock at the top of the print indicating 6:00 GMT (1:00 p.m. EST), the few waves present, and the slight trace of sun glint toward the upper right center of the photograph. (Note also a bright streak near the center of the print which was not present in the RC-8 film from which this print was made). Figure 6.1 is a contour plot of the tape edit corresponding to Figure 6.2. The speckled appearance of the plot is due to noise peaks crossing the chosen contour level in regions of shallow water. The extra dots near elements 460-480 are probably due to waves combined with what little "sun glint" there was during this run. Figures 6.3 through 6.12 were all generated from data in the edit contoured in Figure 6.1.

Figures 6.3, 6.4, 6.6-6.12 are examples of the level of noise which was prevalent in channels 1, 2, 4, 5, 8 and 12-15. Note that while Figure 6.4 shows no particular evidence of the motor spikes present during this run, an average of 100 scan lines for this same channel (channel 2 - Figure 6.5) indicates that motor spikes are an influence. This amount of influence is quite small, however, for all channels with the exception of channels 13-15, where motor spikes are quite pronounced (see Figures 6.10-6.12). Note that in applications where blocks of data might be averaged and processed as averages, normal Gaussian noise would tend to average out while motor spikes would tend to persist, possibly causing problems even in those channels where their amplitude is small. Whether motor spikes are present during a given run depends on how the scan motor was brought up to speed.

Channels 3 and 6 had noise similar to that in channel 2 (Figure 6.4), while channels 7, 9, 10, 11 had noise similar to channel 8 (Figure 6.8).

Channels 12 through 15 showed traces of low frequency noise components which were at their worst in channel 15 (see Figures 6.9-6.12). In channels 13 through 15 this noise is probably due to cooler microphonics from the cooler for array 3 although it could also be caused by amplifier drift (see Section 8). Note in Figure 6.13 ($V/H = .022$ compared to $V/H = .16$ in Figure 6.12) that the period of the noise in channel 15 comprises $1/7$ as many resolution elements as at the V/H of Figure 6.12 (i.e. the period of the noise in microseconds is nearly the same). Figure 6.13 may be correlated with Figure 9.1 (a contour plot of the tape edit from which Figure 6.13 was taken) and compared to Figure 6.15 (the same scan line plotted for channel 20) to determine which features of the signal in Figure 6.13 might not be due to noise.

Channel 16 experienced occasional low frequency ripples of noise as indicated in Figure 6.14. In this figure the dynamic range for each scan line is scaled down to fill only one inch from level 0 to level 256.

Note that the noise ripples have an amplitude on the order of $1/2$ the dynamic range set for this channel. This problem may be caused by amplifier drift or noise. The general Gaussian noise in channel 16 was noticeably greater than for channels 17-20.

Noise in channels 20, 21 and 22 is typified in Figures 6.15-6.17 ($V/H = .022$), taken from the edit contoured in Figure 9.1. Note the increase of noise in channels 21 and 22 compared to channel 20. At a V/H of .16 (as would be expected) the noise in these channels was 2 to 3 times greater than shown for a V/H of .022. Channels 17 through 19 were similar in noise level to channel 20. The increasing noise level in channels 21 and 22 and the increased Gaussian noise level in channel 16 relative to channels 17-20 was probably due to deficient cooling near the ends of array 4. This same noise trend has been apparent in previous MSDS data.

Noise in channels 23 and 24 can be judged from Figures 6.26 and 6.27, to be discussed later in this section.

Some additional phenomena are noteworthy:

Channel 3 was plagued by a few unusual problems. Figures 6.18 and 6.19 show superimposed traces for 5 adjacent resolution elements traced across all scan lines in an edit from run 12 (4 June) for channels 2 and 3. These particular resolution elements coincide with the five gray reflectance panels (scan lines 3466-3511) and with one sequence of the resolution chart painted on the ramp (scan lines 3512-3564) plus one bar from the other sequence of the resolution chart (scan lines 3564-3573), all of which is clearly visible in channel 2 (Figure 6.18). Channel 3, however, shows clipping occurring at digital level 111 for much of the data (Figure 6.19). The spike appearing for scan line 3570 in Figure 6.19 is data from channel 4 which swapped with channel 3 during this scan line due to a problem reading the original flight tape during the generation of our edits (see comment at end of Section 10). The differing response of channels 2 and 3 prior to scan line 3456 is due to spectral differences in these channels while viewing grass near the edge of a road and the O.D. panels at the north end of the ramp (see Figures 1.2 and 1.6). Figures 6.20 and 6.21 show a segment from a single scan line for channels 2 and 3. Note the high signal level corresponding to the sand blasted aluminum panel in channel 2 (near resolution element 390 - Figure 6.20) which is missing entirely from the response of channel 3 (Figure 6.21). Note also the characteristic clipping in channel 3 between elements 405 and 419 (Figure 6.21). Finally note the ringing which occurs at each sudden step in the signal in channel 3 (compare with channel 2). The wavy portion of the scan line in Figures 6.20 and 6.21 between elements 335 and 367 is caused by scanning in and out of phase with the tar paper strips laid out on the ramp (see Figures 1.2 and 1.6) and is discussed in Section 10. Figures 6.22 and 6.23 show single resolution elements traced across all scan lines in edits from two successive runs for channel 3. Note the clipping apparent in Figure 6.22 (at level 123 this time), but note especially the much noisier signal in Figure 6.23 (run 19 - "noise" effect not due to signal drift between successive scan lines). Noise in channel 3 was back

to normal again during run 20. We currently have no explanation for these three anomalies in the behavior of channel 3 other than to conclude that they are intermittent and are probably due to more than one problem source.

Figures 6.24 and 6.25 are segments of one scan line from a run on 2 June for channels 13 and 14. During this particular run, both of these channels experienced brief, intermittent bursts of noise. Note that for this scan line segment, these bursts of noise appear to alternate between the two channels. These noise bursts are probably due to cooler microphonics.

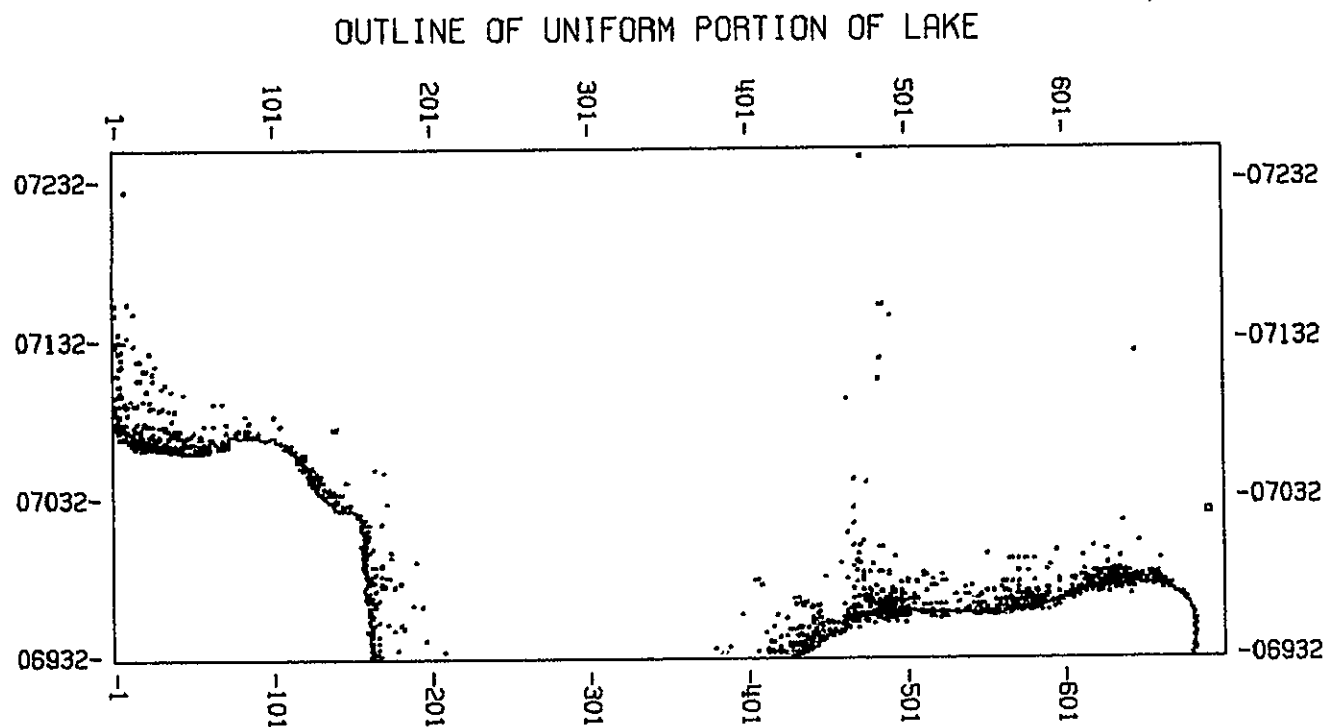
Figures 6.26 and 6.27 (taken from the edit contoured in Figure 9.1) show samples of an intermittent problem in channels 23 and 24. In this case the 32 bit is stuck on zero for both channels, causing data from digital levels 32-63, 96-127, etc. to be displayed at levels 0-31, 64-95, etc., respectively. Digital hang-ups of this general nature were observed from time to time in other channels as well, though not as frequently as in channels 23 and 24 (e.g., a 64 bit sticking on 1 in channel 20).

Figure 6.28 shows evidence of power supply noise spikes at periodic intervals in channel 23 during run 13 (4 June). These spikes probably arise from the power source for channels 1-3 which had been put in just prior to the June flights as a temporary fix so that channels 1-3 could be operating.

Figure 6.1

MSS154-72-8, F2 L2 R12 (OVERCAST) 1.7K, BELLEVILLE LAKE 06/15/72)
V/H=0.1682 LOW TEMP=+11.0°C $\Delta T=38.7^{\circ}\text{C}$ FILTER SELECT=1 3.878 $\mu\text{SEC/ELEMENT}$
SEGMENT 1 OF 1
CHANNEL 8: CAL 2. SCALE= 1X . OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 01:43:12 AUG 22, 1972 *
(CONTOUR, VERSION 2.0, P.F. LANBECK)
CONTOUR AT LEVEL 42 - 1 LINE X 1 ELEMENT AVERAGING
PLOT ALL LINES, ALL ELEMENTS



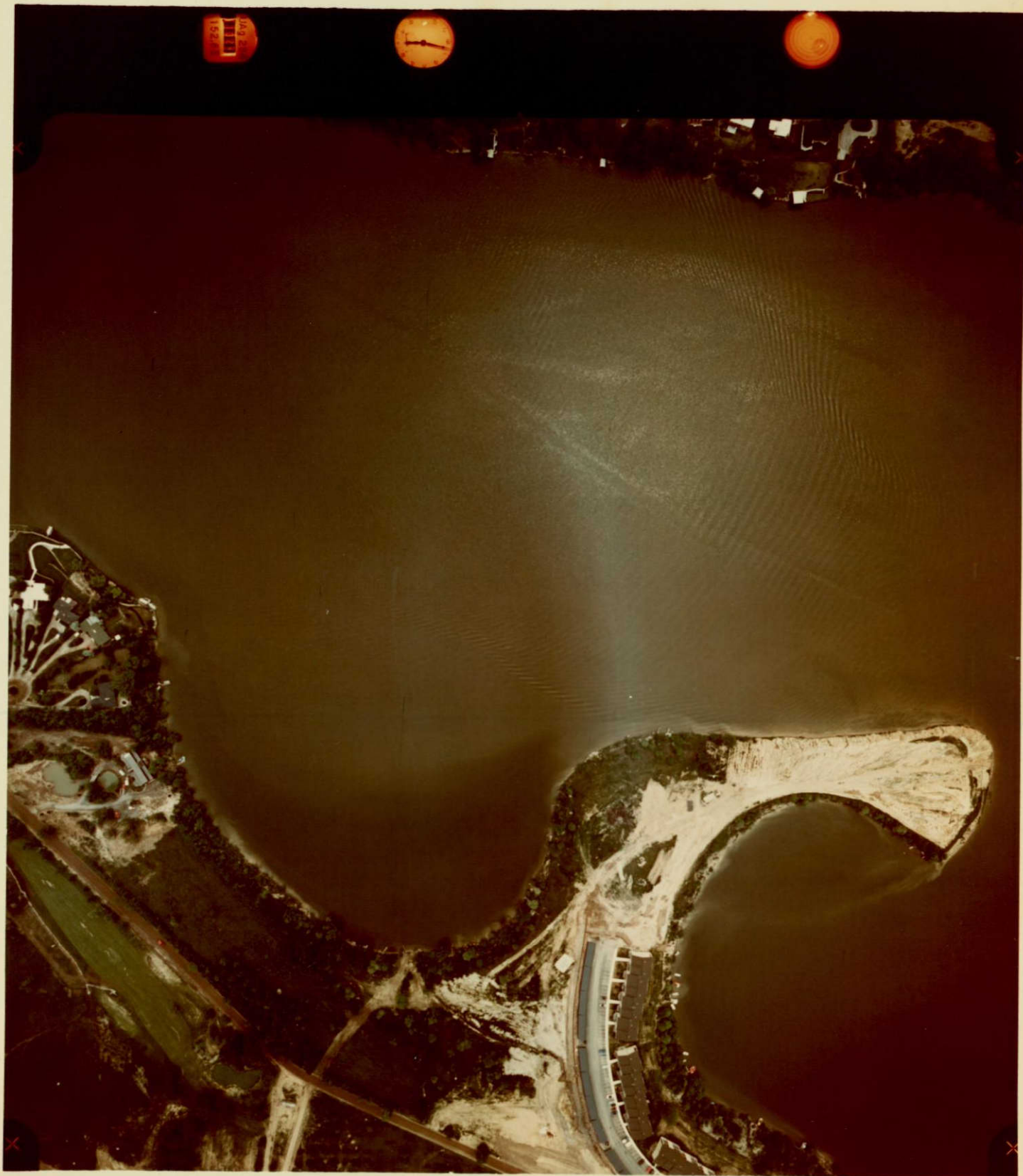


Figure 6.2
1.7K ft. over lake
6/2/72 (overcast)

NSS154-72-8, F2 L2 R12 (OVERCAST) 1.7K, BELLEVILLE LAKE 08/16/72)

V/H=0.1687 LOW TEMP=+11.0°C $\Delta T=36.7^{\circ}\text{C}$ FILTER SELECT=1 3.978 $\mu\text{SEC/ELEMENT}$

SEGMENT 1 OF 1

CHANNEL 1: CAL 2. SCALE= 1X . OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN -11:00:21 SEP 7, 1972 *

(SMALLPLOT, VERSION 2.0, P.F. LAMBECK)

PLOT LINE 7151, ALL ELEMENTS, AND CAL SOURCES

SINGLE SCAN LINE OVER LAKE

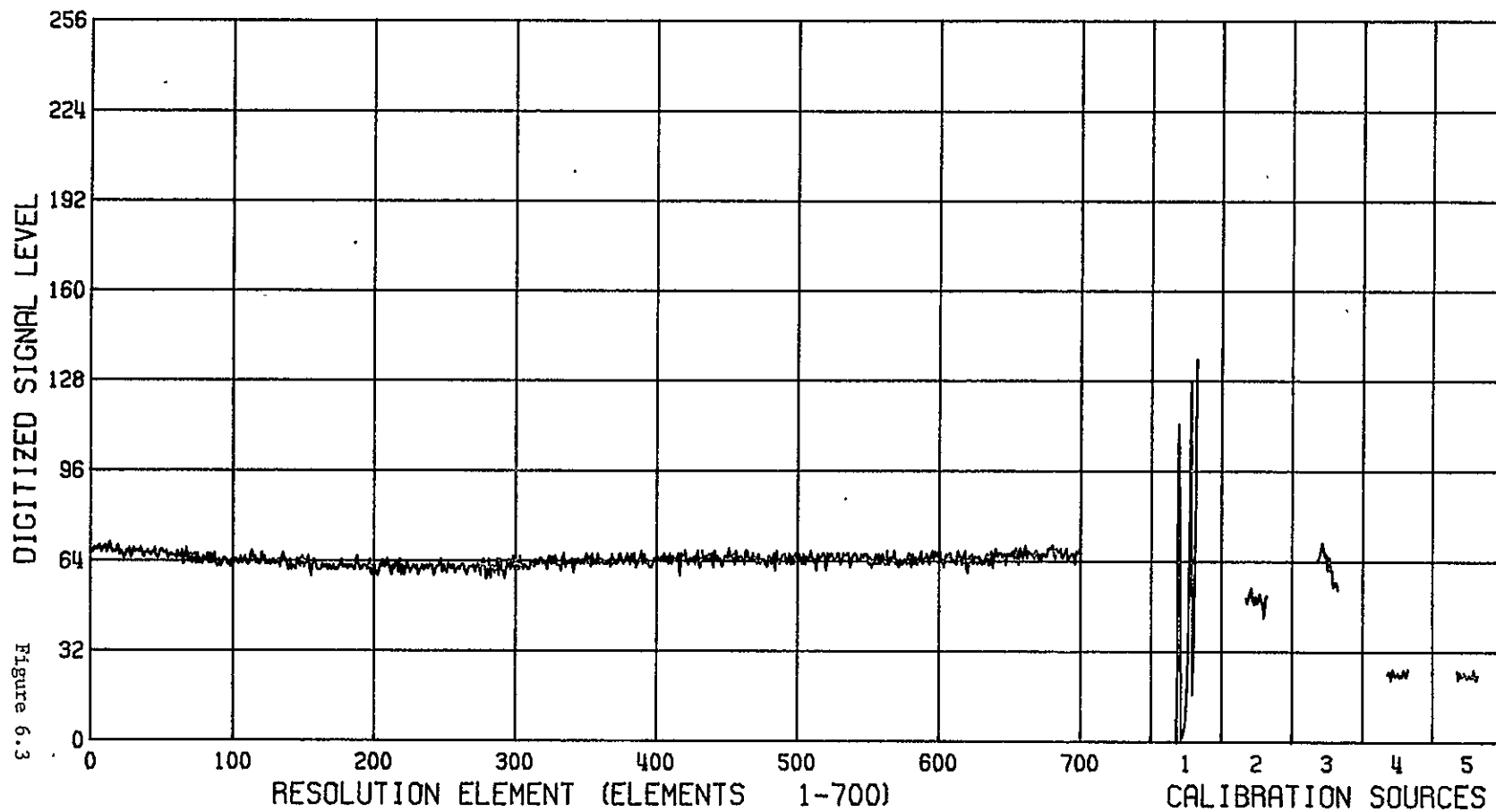
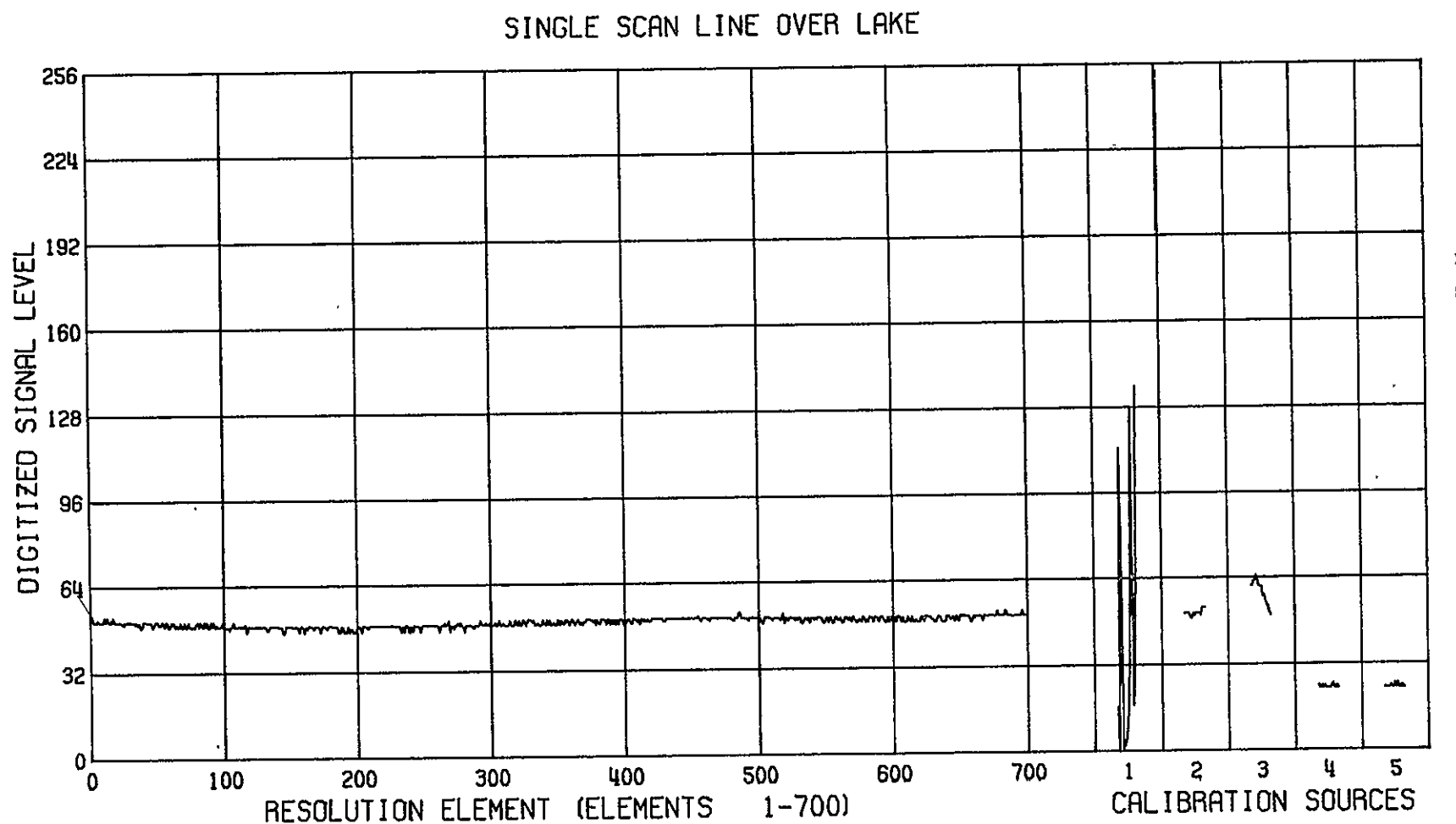


Figure 6.4

HSS154-72-B, F2 L2 M12 (OVERCAST) 1.7K, BELLEVILLE LAKE 06/15/72)
V/M=0.1687 LOW TEMP=+11.0°C ΔT=36.7°C FILTER SELECT=1 3.878uSEC/ELEMENT
SEGMENT 1 OF 1
CHANNEL 2: CAL 2. SCALE= 1X , OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:00:21 SEP 7, 1972 *
(SMALLPLOT, VERSION 2.0, P.F. LAMBECK)
PLOT LINE 7151, ALL ELEMENTS, AND CAL SOURCES



M93154-72-B, F2 L2 M12 (OVERCAST) 1.7K, BELLEVILLE LAKE (06/15/72)

V/H=0.1687 LOW TEMP=+11.0°C $\Delta T=36.7^{\circ}\text{C}$ FILTER SELECT=1 9.979 $\mu\text{SEC/ELEMENT}$
SEGMENT 1 OF 1
CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:14:28 SEP 7, 1972 *
(SMALLPLOT, VERSION 2.0, P.F. LANBECK)
AVERAGE LINES 7151-7250, ALL ELEMENTS, AND CAL SOURCES

AVERAGE OF 100 SCAN LINES OVER LAKE

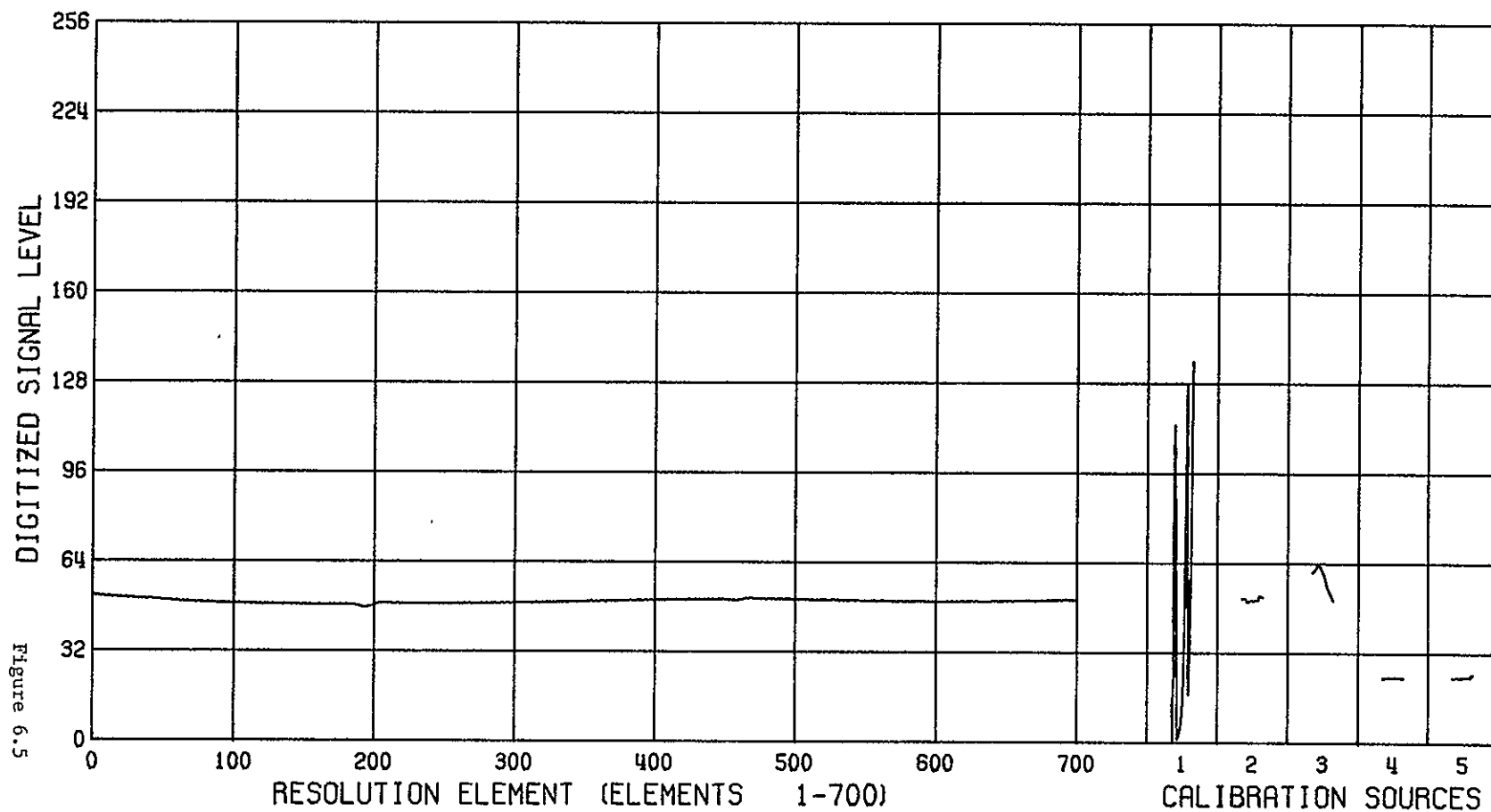
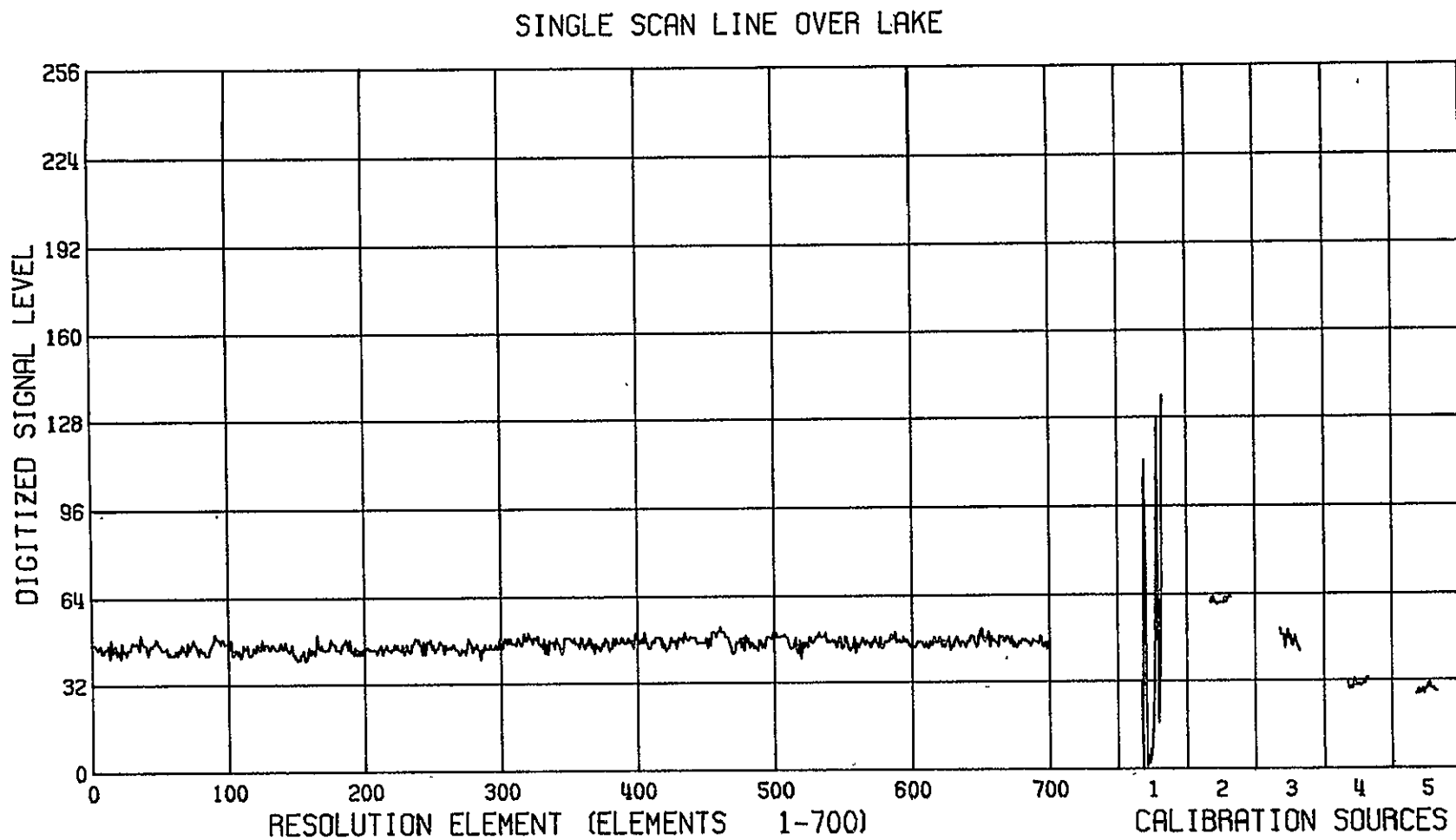


Figure 6.6

HSS154-72-B, F2 L2 M12 (OVERCAST) 1.7K, BELLEVILLE LAKE 086/15/72
V/T=0.1687 LOW TEMP=+11.0°C ΔT=36.7°C FILTER SELECT=1 3.978μSEC/ELEMENT
SEGMENT 1 OF 1
CHANNEL 4: CAL 2. SCALE= 1X . OFFSET=1

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:00:21 SEP 7, 1972 "
SMALLPLOT, VERSION 2.0, P.F. LANDECKO
PLOT LINE 7151, ALL ELEMENTS, AND CAL SOURCES



W03154-72-8. F2 L2 R12 (OVERCAST) 1.7K. BELLEVILLE LAKE 096/15/72)
V/A=0.1887 LOW TEMP=11.0°C ΔT=36.7°C FILTER SELECT=1 3.978/SEC/ELEMENT
SEGMENT 1 OF 1
CHANNEL S: CAL 2. SCALE= 1X . OFFSET=1

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:09:21 SEP 7, 1972
(SMALLPLOT, VERSION 2.0. P.F. LANBECK)
PLOT LINE 7151, ALL ELEMENTS, AND CAL SOURCES

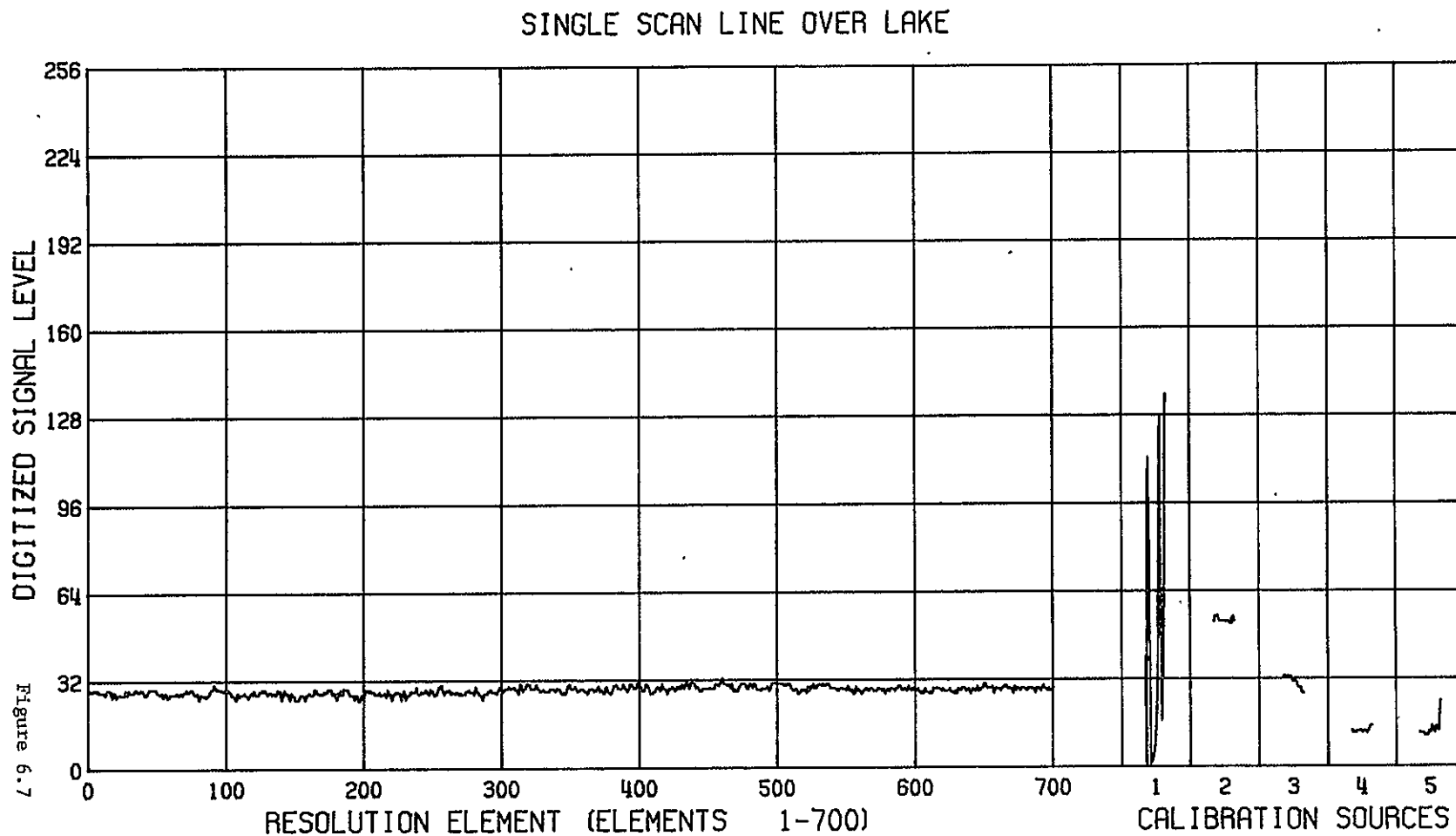
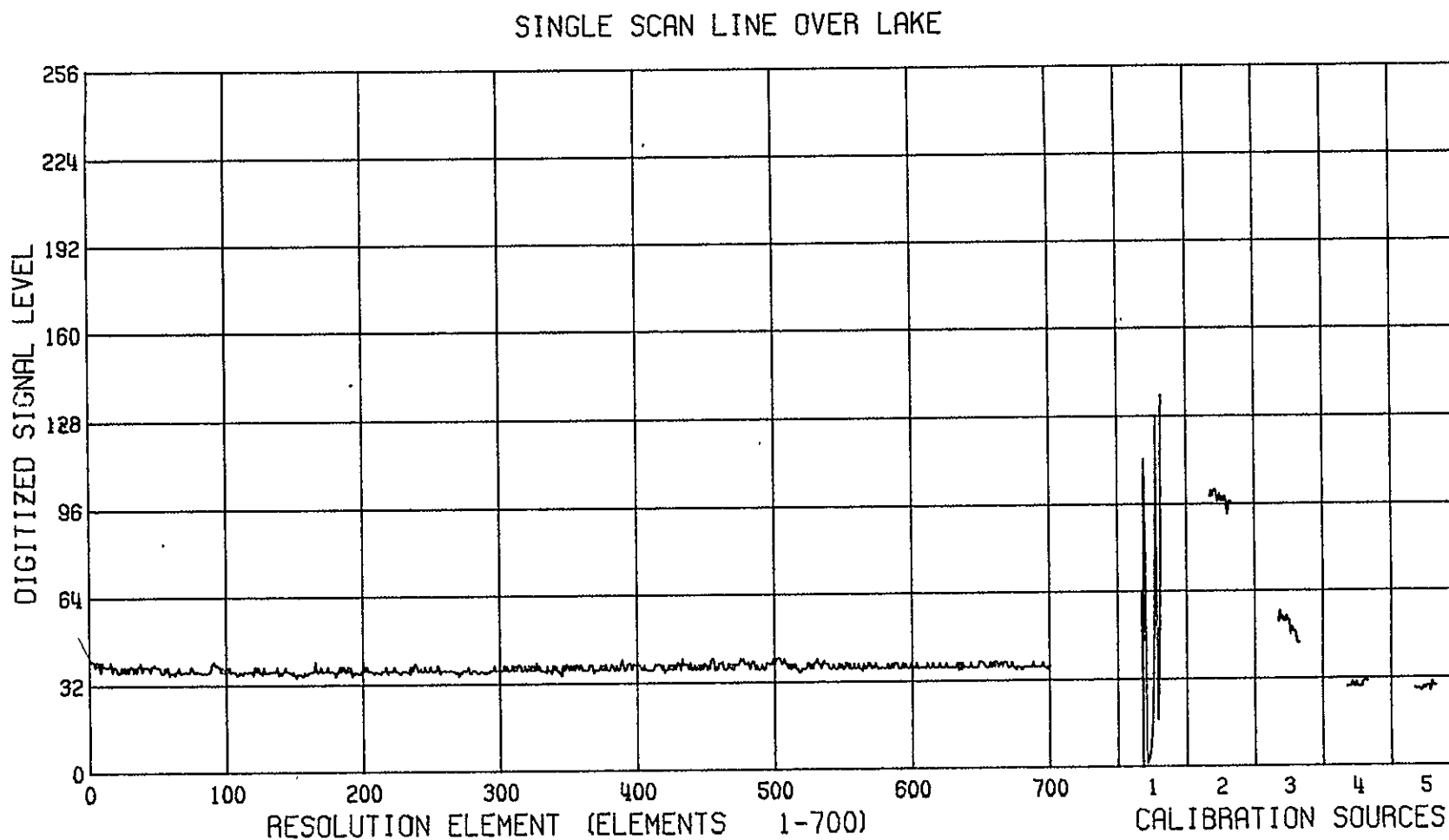


Figure 6.8

MSS154-72-B, F2 L2 R12 (OVERCAST) 1.7K, BELLEVILLE LAKE (06/15/72)
V/H=0.1687 LOW TEMP=+11.0°C $\Delta T=36.7^{\circ}\text{C}$ FILTER SELECT=1 3.879 $\mu\text{SEC/ELEMENT}$
SEGMENT 1 OF 1
CHANNEL 0: CAL 2, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:08:21 SEP 7, 1972 *
SMALLPLOT, VERSION 2.0, P.F. LAMBECK
PLOT LINE 7151, ALL ELEMENTS, AND CAL SOURCES



MS9154-72-8, F2 L2 R12 (OVERCAST) 1.7M, BELLEVILLE LAKE (06/15/72)

V/H=0.1687 LOW TEMP=-11.0°C ΔT=36.7°C FILTER SELECT=1 3.979μSEC/ELEMENT

SEGMENT 1 OF 1

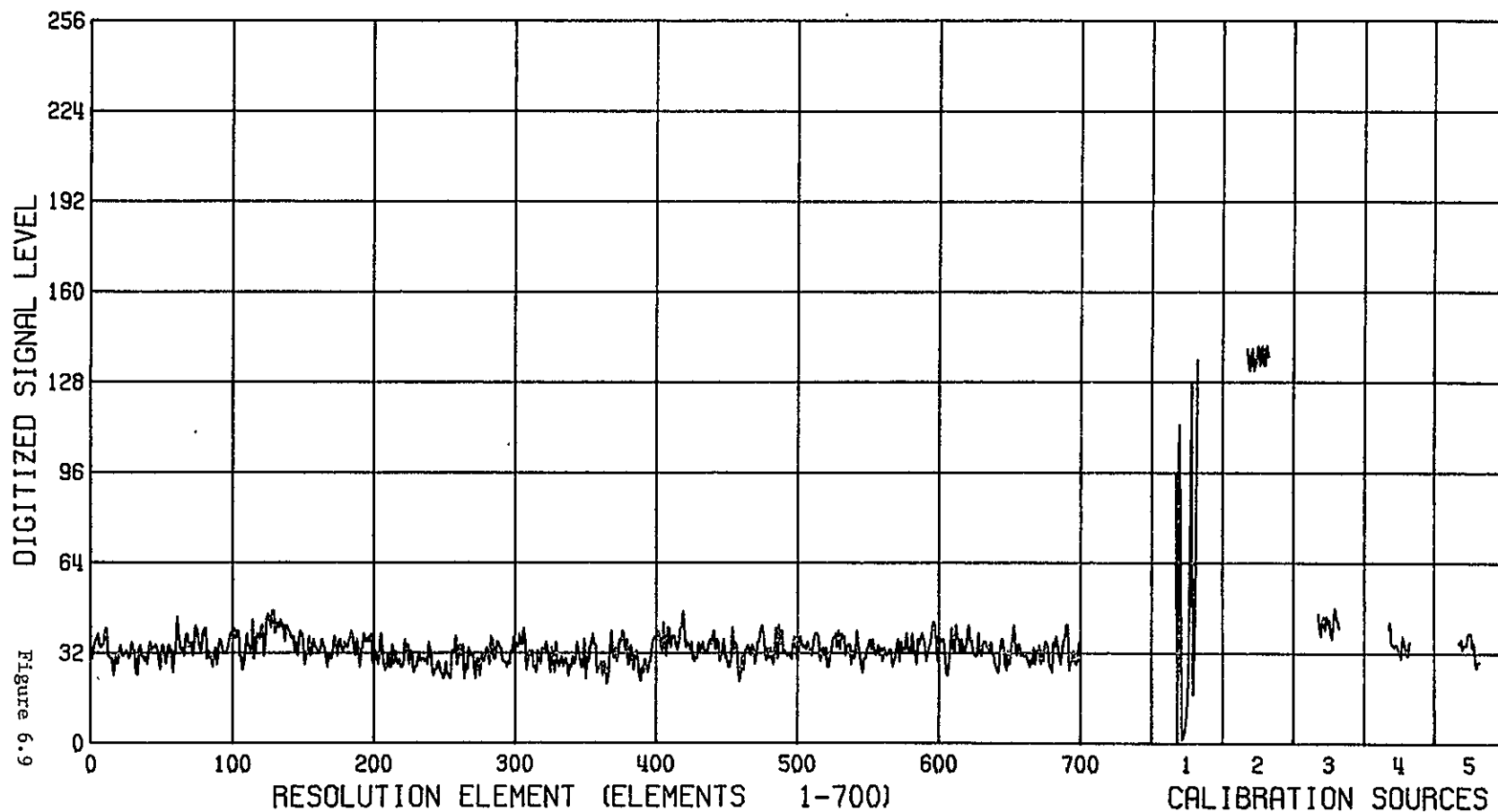
CHANNEL 12; CAL 2, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:09:21 SEP 7, 1972 *

(SMALLPLOT, VERSION 2.0, P.F. LAMBECK)

PLOT LINE 7151, ALL ELEMENTS, AND CAL SOURCES

SINGLE SCAN LINE OVER LAKE

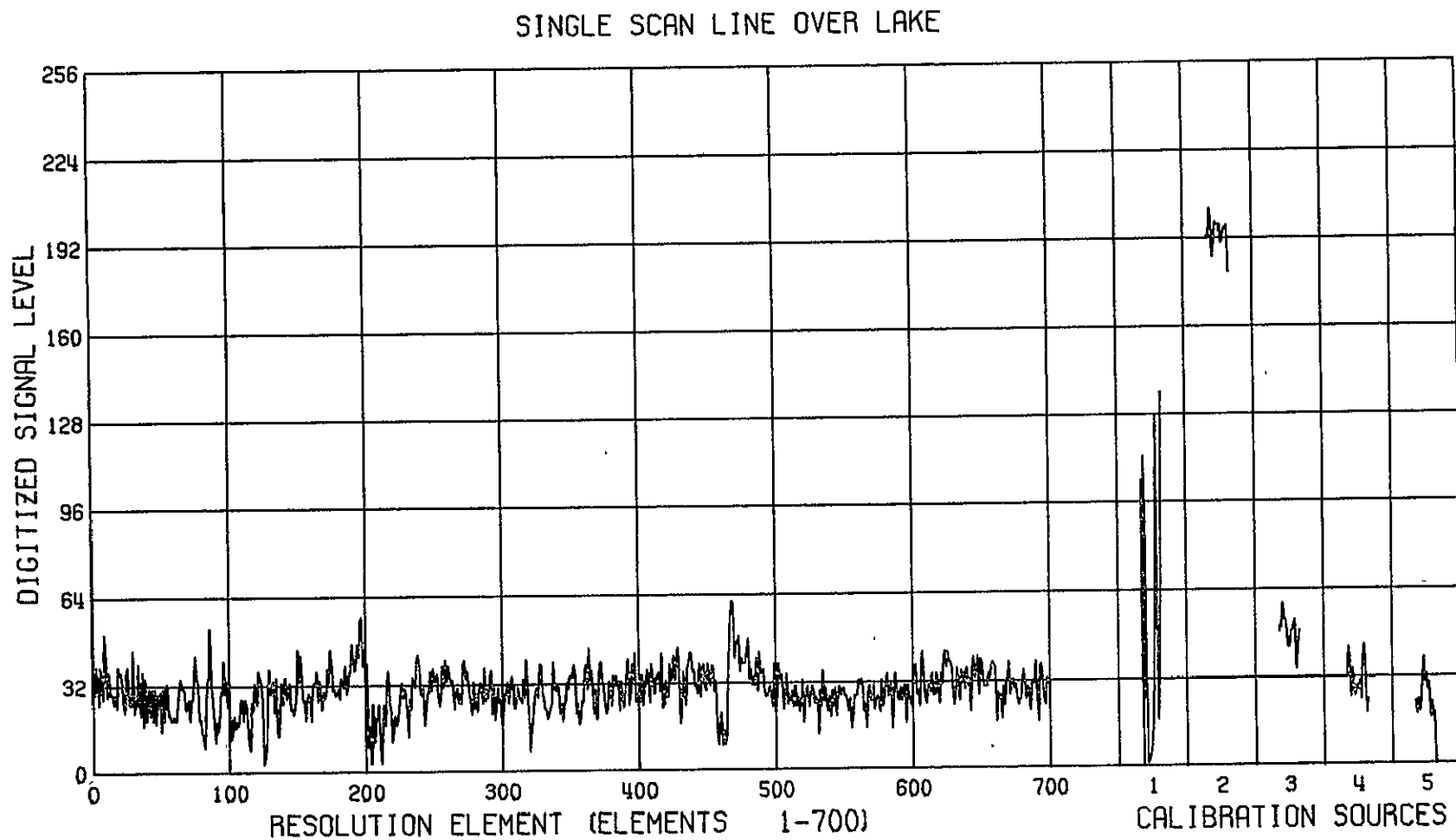


NSS154-72-B, F2 L2 R12 (OVERCAST) 1.7K, BELLEVILLE LAKE 08/15/72)

V/H=0.1687 LOW TEMP=+11.0°C ΔT=36.7°C FILTER SELECT=1 3.979μSEC/ELEMENT
SEGMENT 1 OF 1
CHANNEL 13; CAL 2. SCALE= 1X . OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:09:21 SEP 7, 1972 *
(SMALLPLOT, VERSION 2.0, P.F. LAMBECK)
PLOT LINE 7151. ALL ELEMENTS, AND CAL SOURCES

Figure 6.10



NSS154-72-8, F2 L2 R12 (OVERCAST) 1.7K, BELLEVILLE LAKE (06/15/72)

V/M=0.1687 LOW TEMP=-11.0°C $\Delta T=36.7^{\circ}\text{C}$ FILTER SELECT=1 3.979 $\mu\text{SEC/ELEMENT}$

SEGMENT 1 OF 1

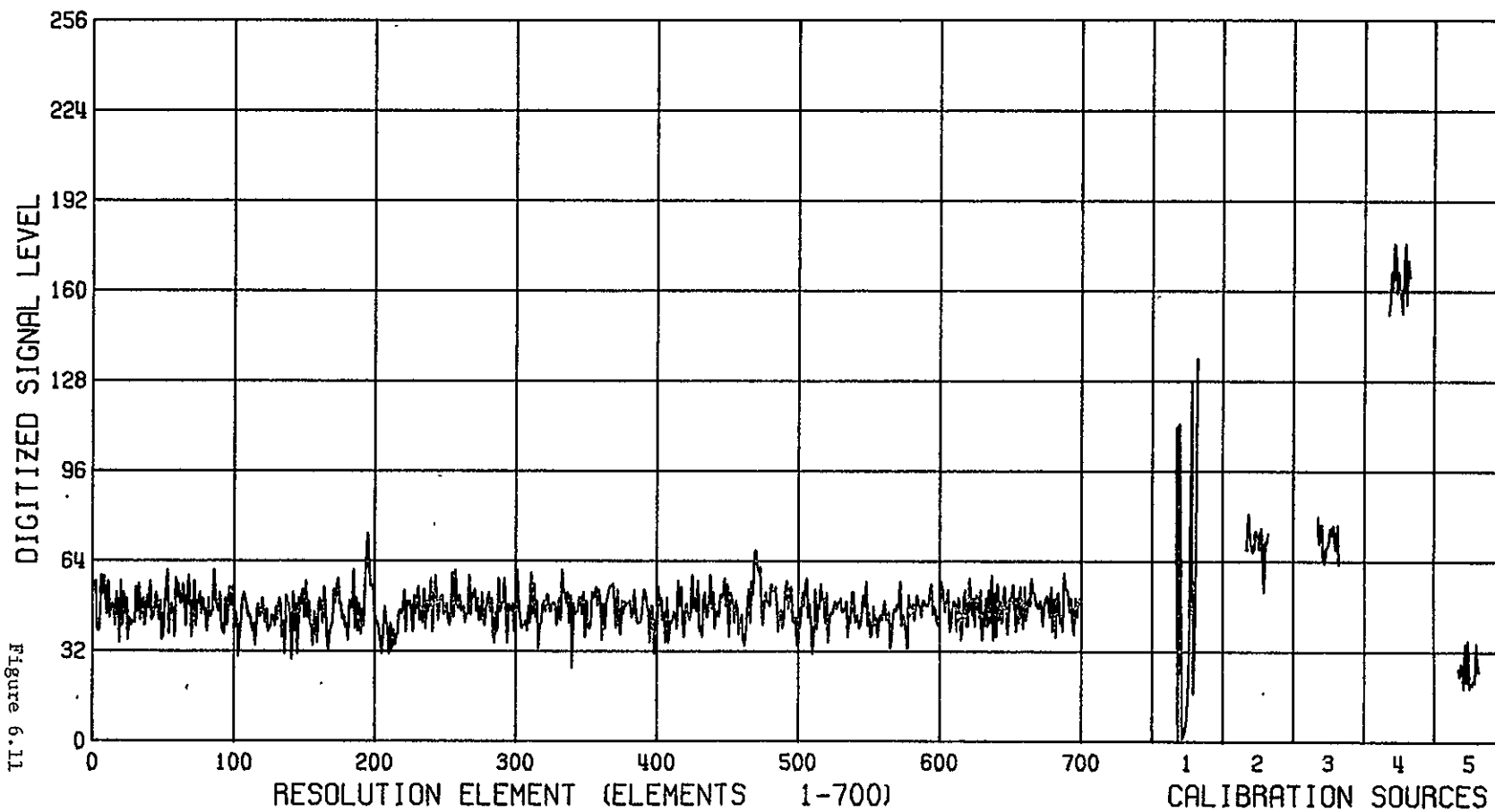
CHANNEL 14: CAL 1, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:09:21 SEP 7, 1972 *

SMALLPLOT, VERSION 2.0, P.F. LANBECK

PLOT LINE 7151, ALL ELEMENTS, AND CAL SOURCES

SINGLE SCAN LINE OVER LAKE

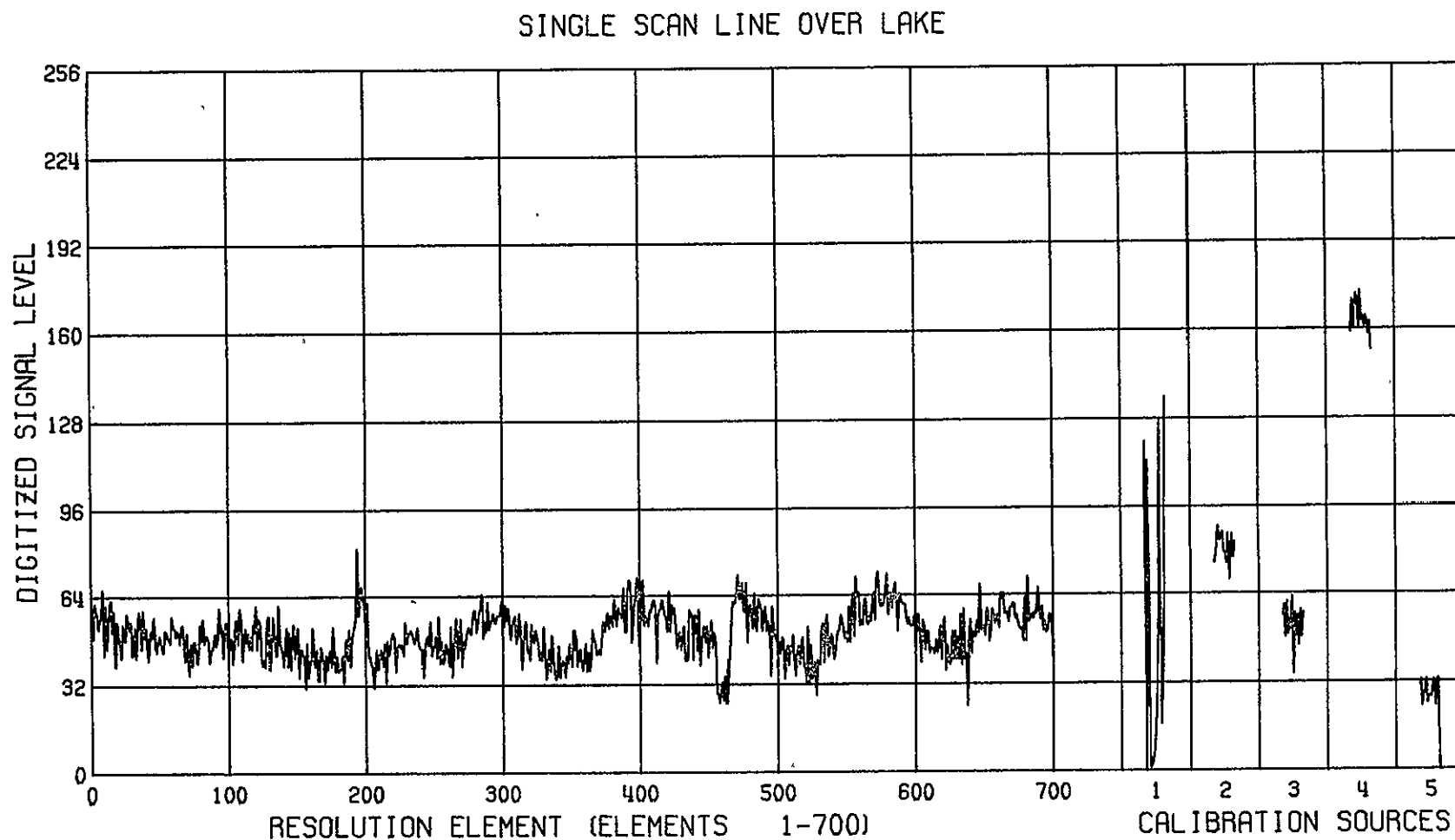


M93154-72-B, F2 L2 R12 (OVERCAST) 1.7K, BELLEVILLE LAKE (06/15/72)

V/H=0.1687 LOW TEMP=+11.0°C AT=36.7°C FILTER SELECT=1 3.979μSEC/ELEMENT
SEGMENT 1 OF 1
CHANNEL 15: CAL 1. SCALE= 1X . OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 11:09:21 SEP 7, 1972 *
(SMALLPLOT, VERSION 2.0, P.F. LAMBECK)
PLOT LINE 7151, ALL ELEMENTS, AND CAL SOURCES

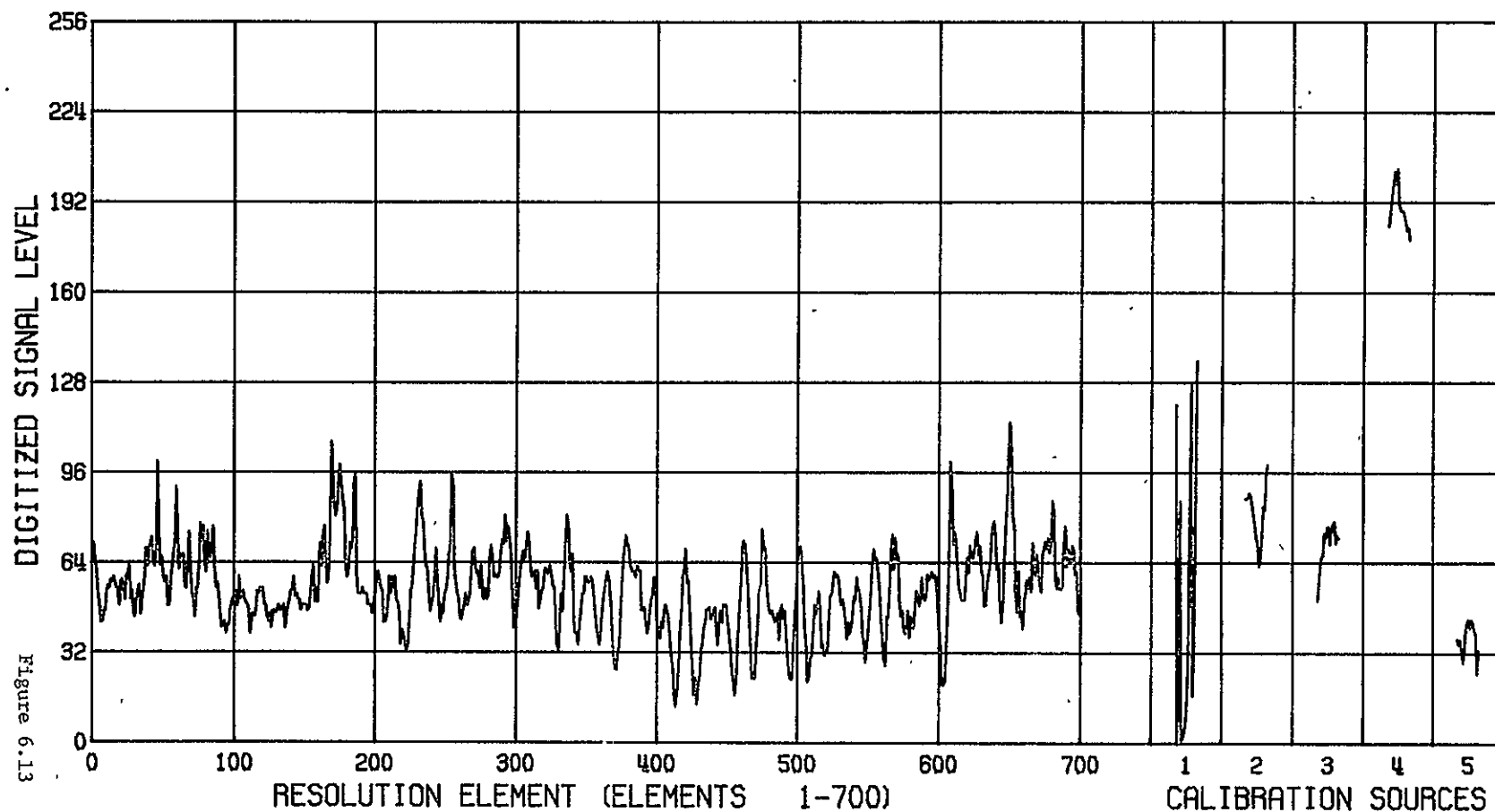
Figure 6.12



MS158-72-B, F3 L2 R2 (CLEAR) 14.7K, BELLEVILLE LAKE (08/15/72)
 08/04/72 15:37:41.4, RADAR ALT 14500 FT, TRUE HEADING 186.0°, DRIFT -08.0°
 V/H=0.0287 LOW TEMP=-10.8°C AT=38.2°C FILTER SELECT=1 27.6784SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 15: CAL 1, SCALE= 1X , OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 18:04:50 SEP 8, 1972 *
 (SHALLOT, VERSION 2.0, P.F. LANDECK)
 PLOT LINE 1055, ALL ELEMENTS, AND CAL SOURCES

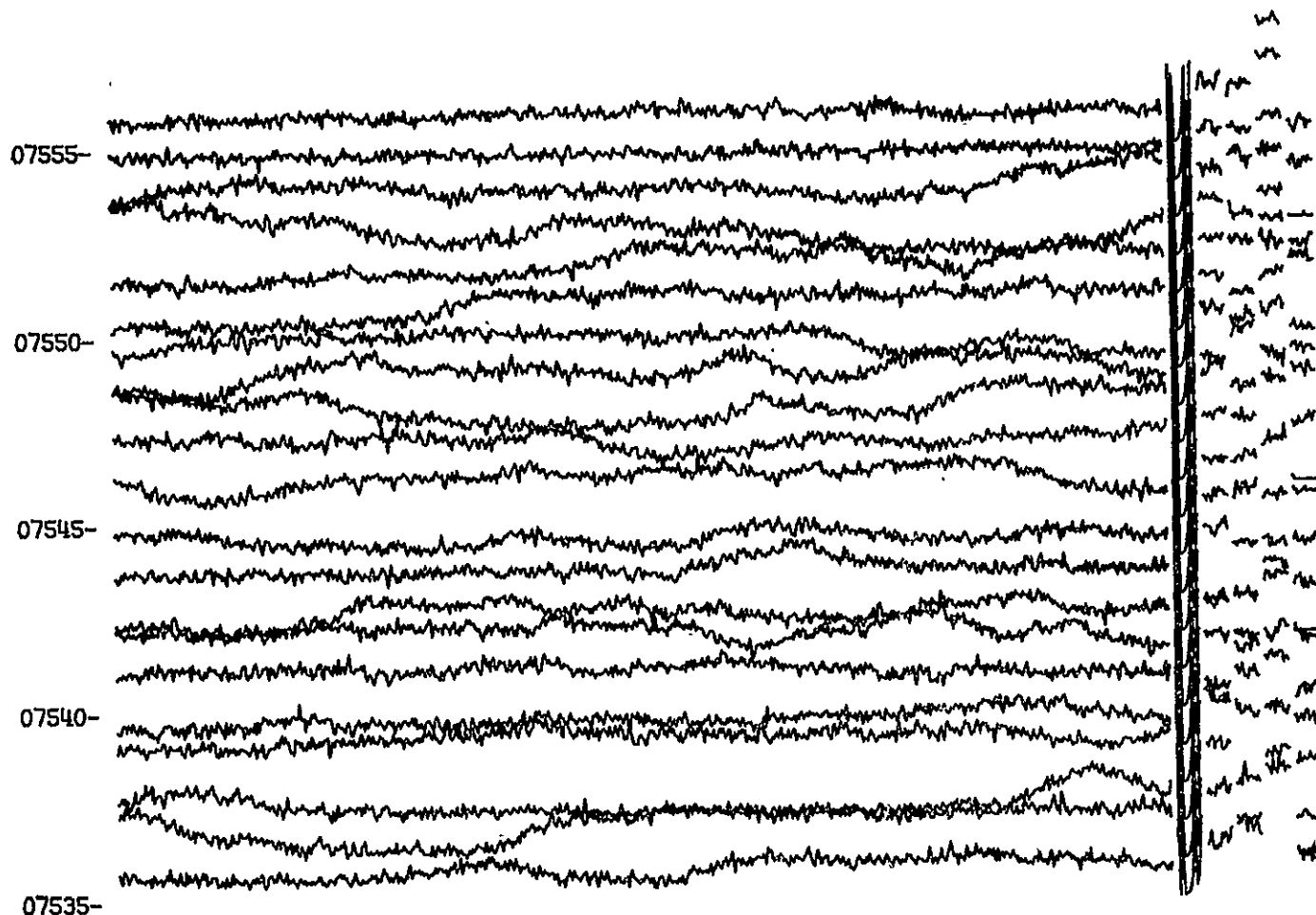
SINGLE SCAN LINE OVER LAKE



NSS158-72-D, F3 L2 R23 (CLEAR) 1.7K, PANELS, ETC. ON RAMP 08/15/72)
 06/04/72 10:44:54.8, RADAR ALT 01610 FT, TRUE HEADING 357.0°, DRIFT -00.0°
 V/H=0.1687 LOW TEMP=+11.1°C $\Delta T=36.5^\circ\text{C}$ FILTER SELECT=1 3.078uSEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 16: CAL 1, SCALE=1X, OFFSET=1
 SCAN LINES 07535-07555, RESOLUTION ELEMENTS 1-700

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 23:00:57 SEP 11, 1972 *
 (ATRACE, VERSION 2.0, P.F. LANDECK)
 1/4 INCH SPACING, 1 INCH MAX AMPLITUDE, 1 LINE X 1 ELEMENT AVERAGING
 PLOT LINES 7535-7555, ALL ELEMENTS, AND CAL SOURCES

CONSECUTIVE A-TRACES FOR A PORTION OF TAPE D, EDIT 9



NSS158-72-B, F9 L2 R2 CLEARO 14.7K, BELLEVILLE LAKE (08/15/72)
 08/04/72 15:37:41.4, RADAR ALT 14500-FT, TRUE HEADING 188.4°, DRAFT -00.6P
 V/H=0.0287 LON TEMP=+10.8°C AT=08.2°C FILTER SELECT=1 27.6794SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 20: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 18:04:50 SEP 8, 1972 *
 SMALLPLOT, VERSION 2.0, P.F. LAMBEZO
 PLOT LINE 1055, ALL ELEMENTS, AND CAL SOURCES

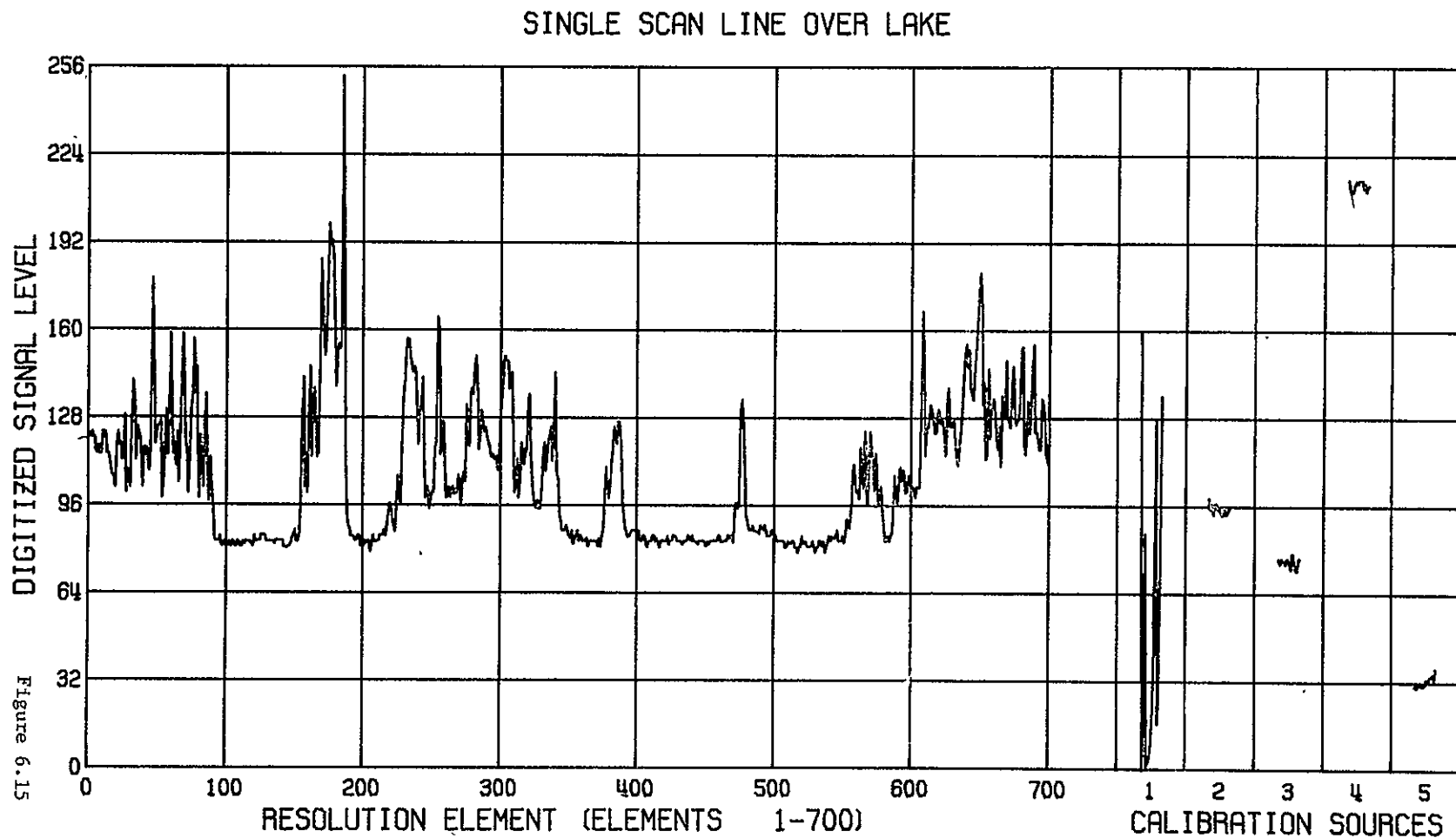


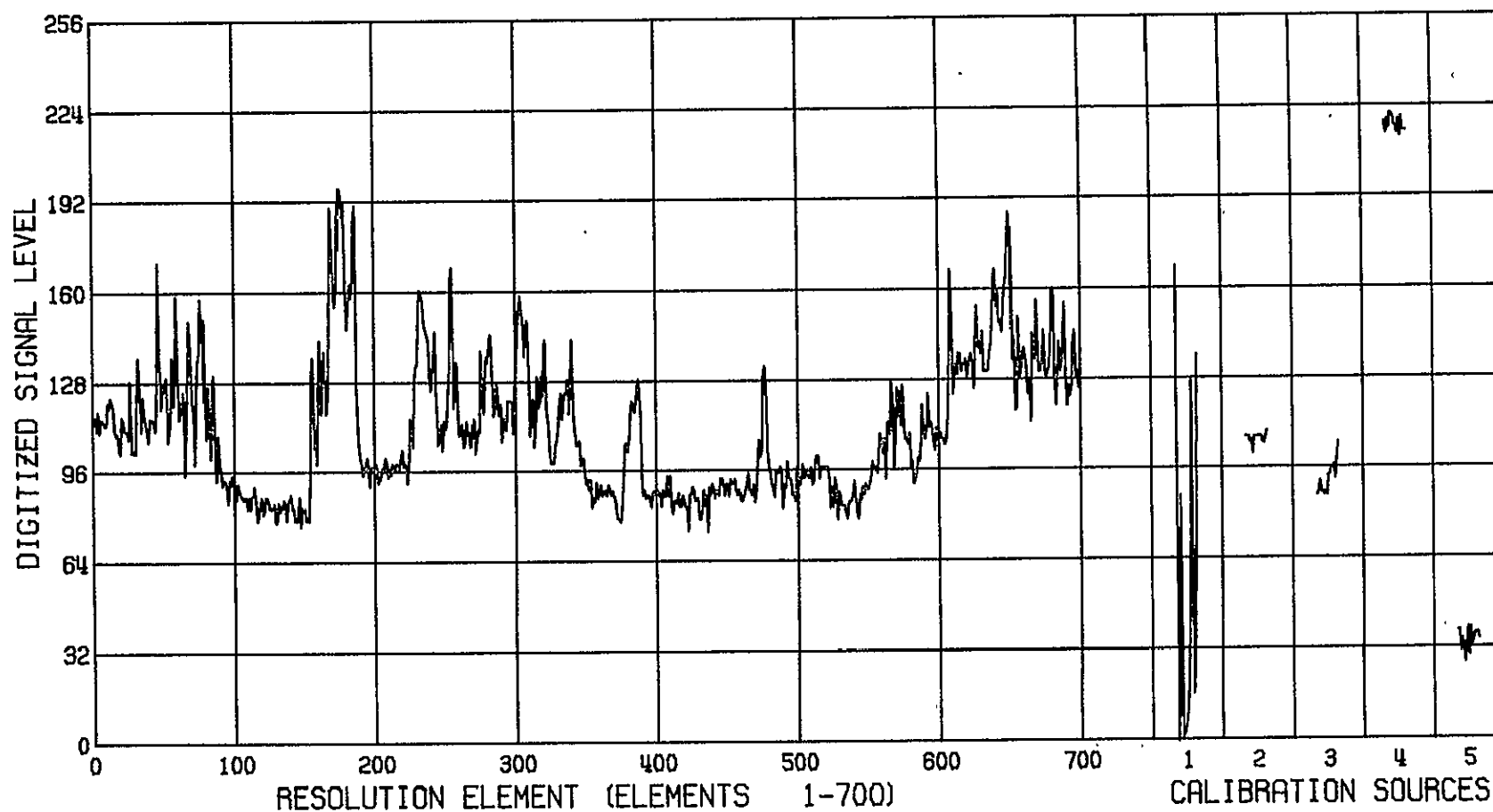
Figure 6.15

Figure 6.16

NSS158-72-8, F3 L2 R2 CLEAR 14.7K, BELLEVILLE LAKE (08/15/72)
 08/04/72 15:37:41.4, RADAR ALT 14500 FT, TRUE HEADING 188.4°, DRIFT -08.0°
 V/H=0.0287°/MIN TEMP=+10.8°C ΔT=38.2°C FILTER SELECT=1 27.8784SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 21: CAL 1, SCALE=1X, OFFSET=1

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 18:04:50 SEP 8, 1972 "
 (SMALLPLOT, VERSION 2.0, P.F. LAMBECK)
 PLOT LINE 1055, ALL ELEMENTS, AND-CAL-SOURCES

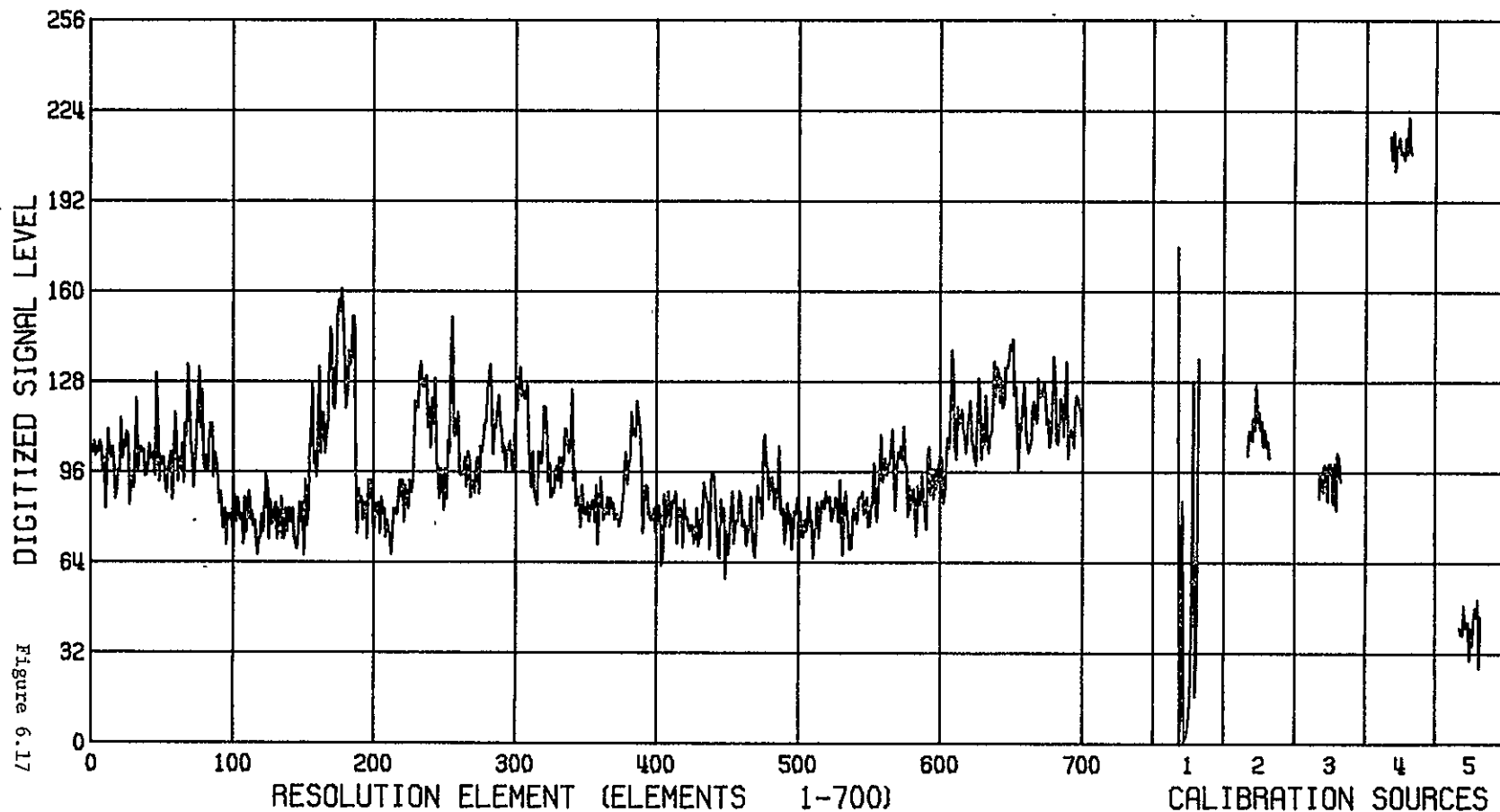
SINGLE SCAN LINE OVER LAKE



MS9158-72-B, F3 L2 R2 (CLEAR) 14.7K, BELLEVILLE LAKE 08/15/72
 08/04/72 15:37:41.4, RADAR ALT 14500 FT, TRUE HEADING 188.4°, DRIFT -08.0°
 V/H=0.0287 LOW TEMP=10.0°C ΔT=38.2°C FILTER SELECT=1 27.6794SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 22: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 18:04:50 SEP 8, 1972 *
 (SHALLPLOT, VERSION 2.0, P.F. LANDECK)
 PLOT LINE 1055, ALL ELEMENTS, AND CAL SOURCES

SINGLE SCAN LINE OVER LAKE



UNIVERSITY OF MICHIGAN 187 INQ. 18:13:28 JUL 5, 1972 = SEGMENT 1 OF 1
 CLARKEPLOT, VERSION 2.0, P.F. LANGECKU
 PLOT ELEMENTS 578-382, LINES 3431-3598

HSS158-72-0, F3 L2 R12 01000 1.7K, PANELS, ETC, ON RAMP #8/15/72)
 08/05/72 16:55:49.0, INDIR ALT 01500 FT, TRUE HEADING 175.5°
 V/H=0.1007 LON TEMP=11.2°C ALT=35.7°C FILTER SELECT=1 3.0704352/ELEMENT
 CHANNEL 2: CXL 2, SCALE=1X, OFFSET=1

FIVE ADJACENT ELEMENTS TRACED ACROSS THE FIVE GRAY PANELS

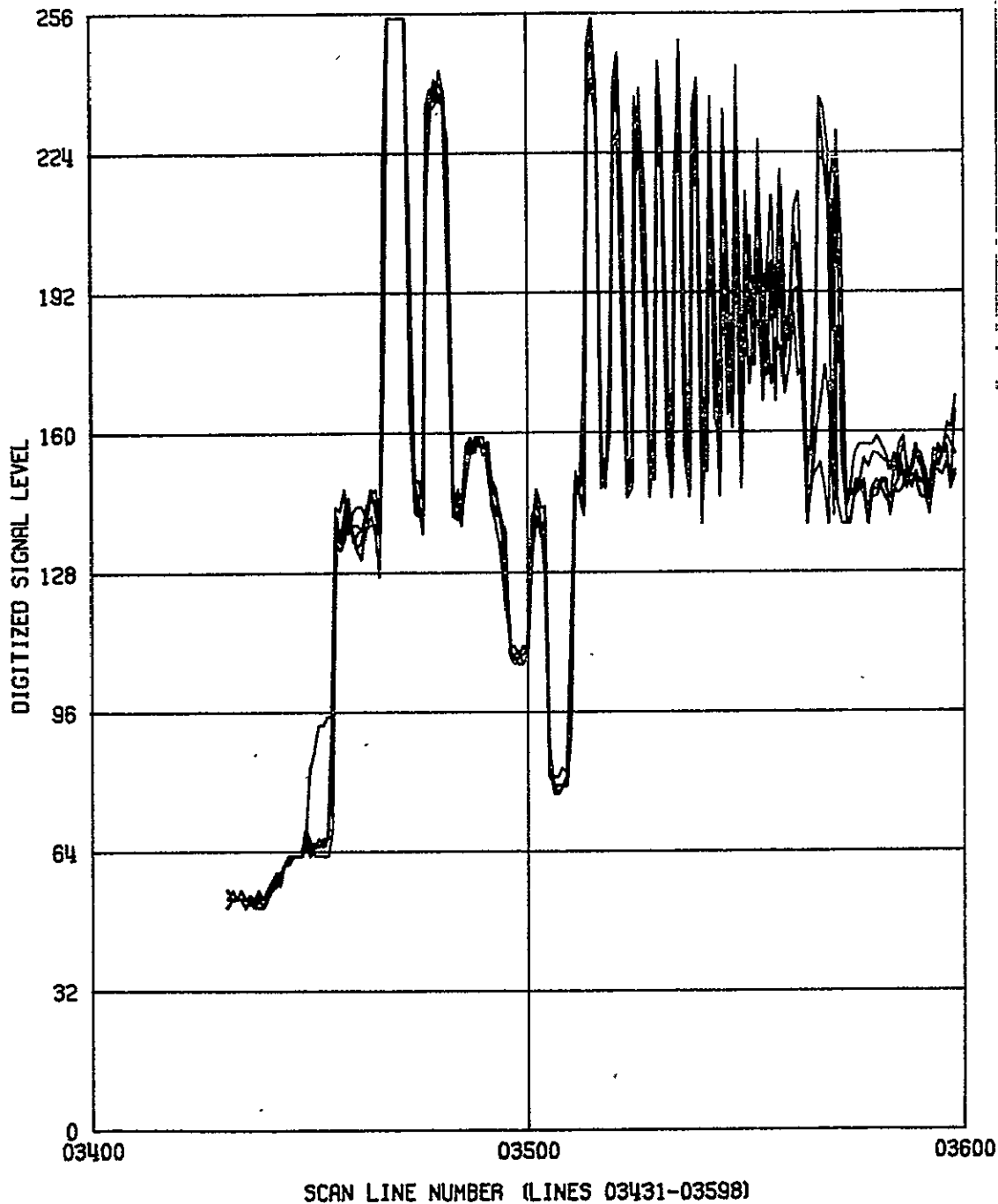


Figure 6.18

H05108-72-0, F3 L2 M12 03400 1.7K, PANELS, ETC. ON RAMP 06/15/72)
 06/04/72 16:56:49.0, RAMP ALT 01500 FT, TRUE HEADING 173.9°
 V/H=0.1807 LON TEMP=11.2°C $\Delta T=26.7^{\circ}\text{C}$ FILTER SELECT=1 3.0704SEC/ELEMENT
 CHANNEL 3: CH1 2, SCALE=1K, OFFSET=1

* UNIVERSITY OF MICHIGAN 1ST INCL 16:13:28 JUL 5, 1972 * SEGMENT 1 OF 1
 CLARKEPLOT, VERSION 2.0, P.F. LAMKOV
 PLOT ELEMENTS 370-382, LINES 3431-3598

FIVE ADJACENT ELEMENTS TRACED ACROSS THE FIVE GRAY PANELS

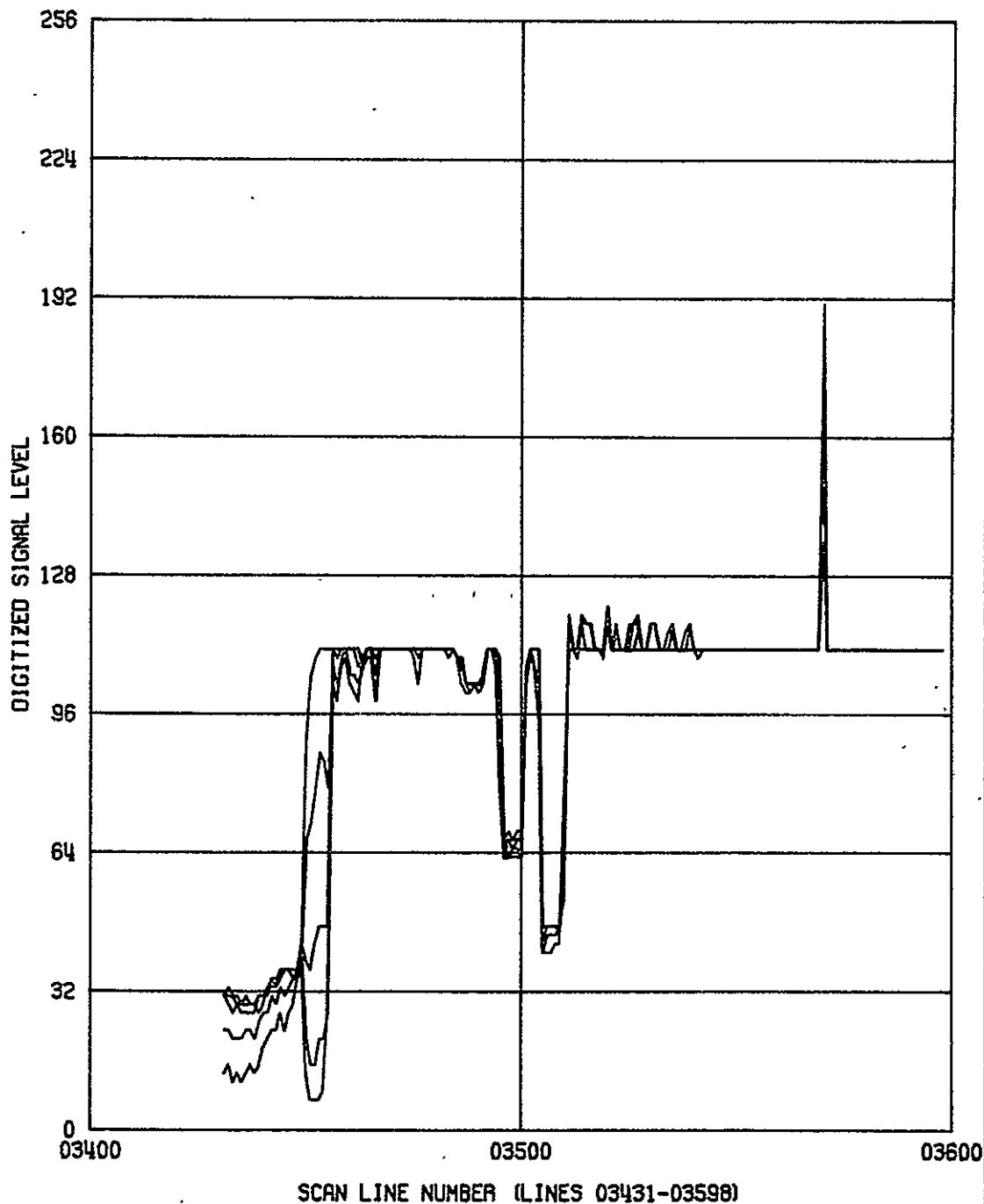


Figure 6.19

* UNIVERSITY OF MICHIGAN 1ST INDL 16:00:58 JUL 5, 1972 * SEGMENT 1 OF 1
 CLAMPLOT, VERSION 2.0, P.F. LAMBDX
 PLOT LINE 3607, ELEMENTS 300-500, AND CHL SOURCES

HSS189-72-0, F3 L2 R12 (CLEAN) 1.7K, PANELS, ETC, ON RAMP 08/15/72)
 06/09/72 18:55:49.6, RADAR ALT 01890 FT, TRUE HEADING 173.9°
 V/A=0.1687 LOW TEMP=11.2°C AT=36.7°C FILTER SELECT=1 3.970-SEC/ELEMENT

CHANNEL 2: CHL 2, SCALE=1X, OFFSET=1

SEGMENT OF SCAN LINE CROSSING 4% GRAY PANEL AND ALUMINUM PANEL

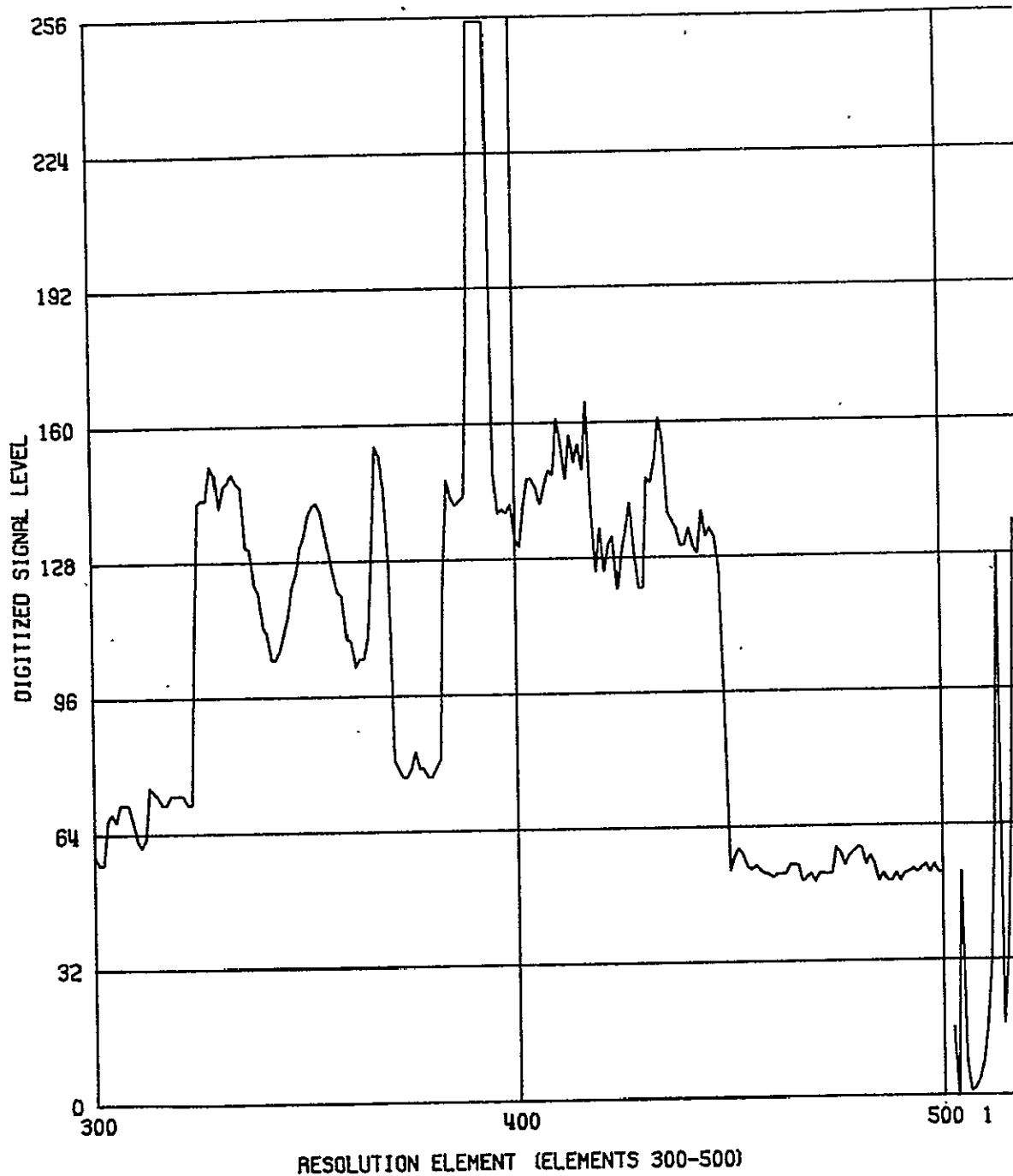


Figure 6.20

UNIVERSITY OF MICHIGAN 1ST INV. 16:00:58 JUL 5, 1972 * SEGMENT 1 OF 1
 CLANGELUT, VERSION 2.0, P.F. LAMBECK
 PLOT LINE 3507, ELEMENTS 300-500, AND CAL BOUNDS

WSS156-72-0, F3 L2 R12 612RN 1.7K, PANELS, ETC. ON RAMP 06/15/72
 06/04/72 16:55:49.3, RADAR ALT 01560 FT, TRUE HEADING 173.5°
 V/H=0.1687 LOW TEMP=11.2°C ΔT=38.7°C FILTER SELECT=1 3.9784SEC/ELEMENT
 CHANNEL 3: CAL 2, SCALE=1X, OFFSET=1

SEGMENT OF SCAN LINE CROSSING 4% GRAY PANEL AND ALUMINUM PANEL

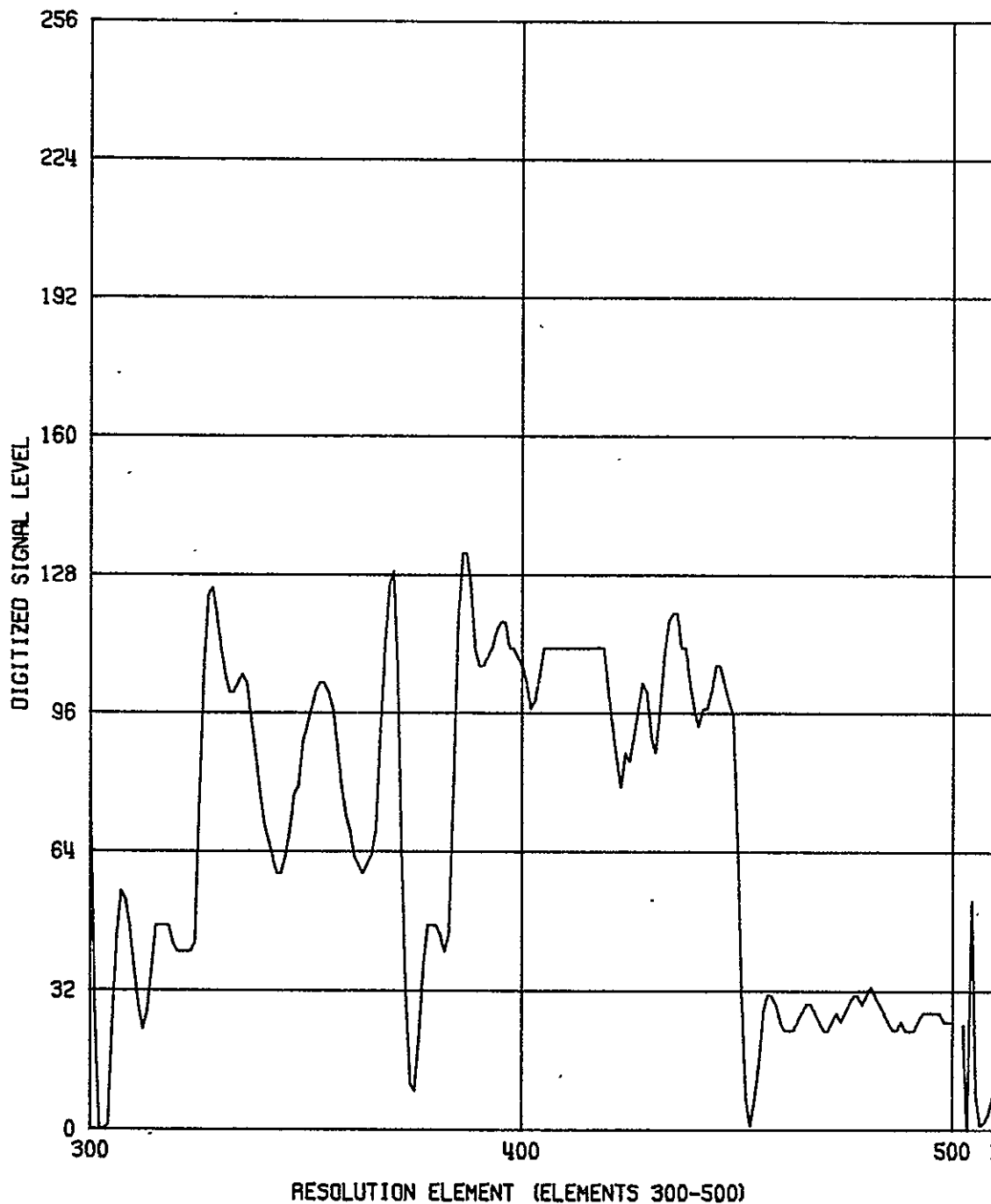


Figure 6.21

NSS168-72-C, F3 L2 A10 CLEARAD 1.5K. PANELS. ETC. ON RAMP (06/15/72)

V/H=0.178 LOW TEMP=+11.2°C $\Delta T=38.6^{\circ}\text{C}$ FILTER SELECT=1 3.557 $\mu\text{SEC/ELEMENT}$

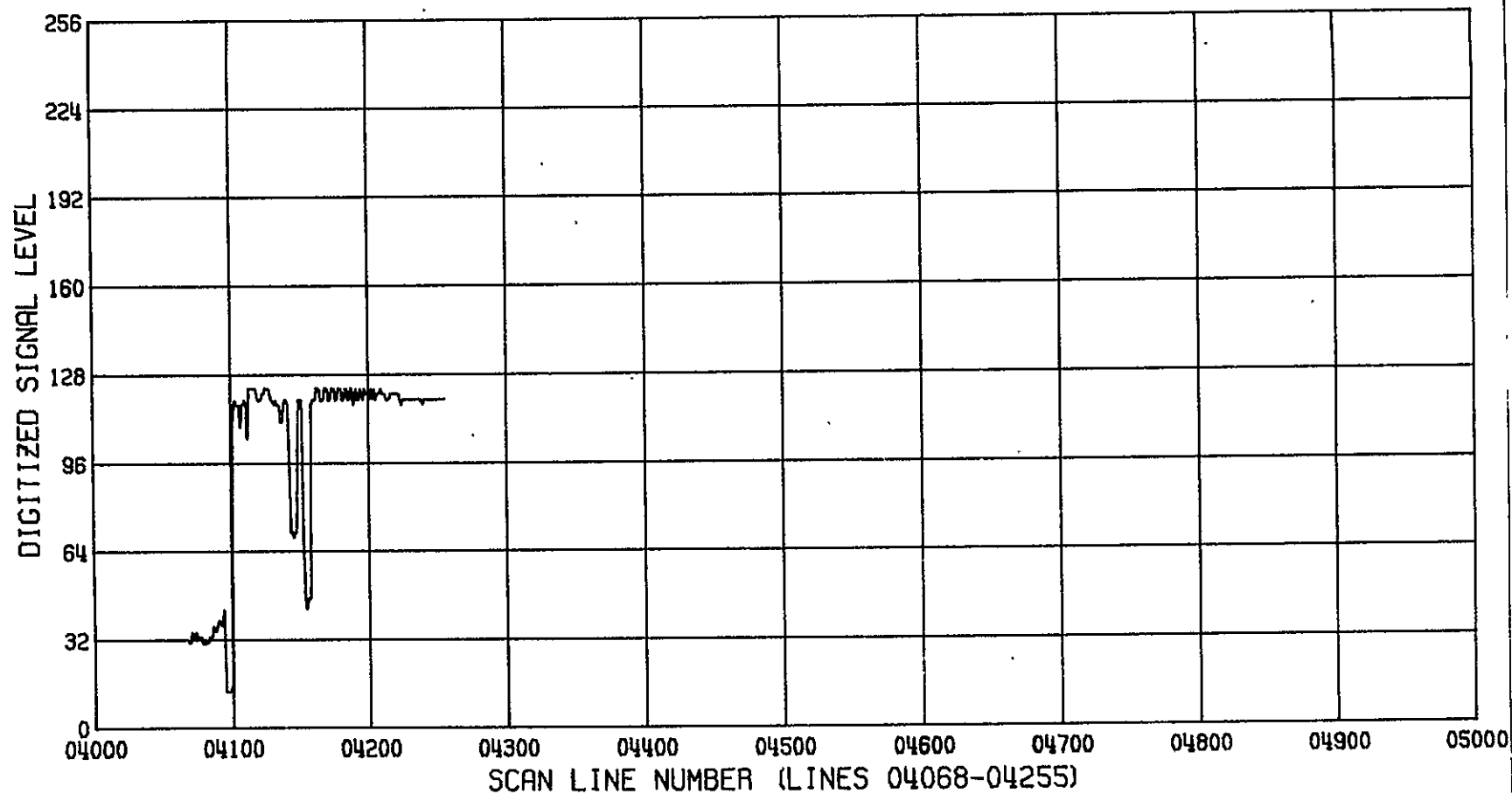
SEGMENT 1 OF 1

CHANNEL 3: CAL 2. SCALE= 1X . OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 18:55:30 SEP 12, 1972 *
SMALLPLOT, VERSION 2.0, P.F. LANGECK
PLOT ELEMENT 372, ALL LINES

Figure 6.22

SINGLE ELEMENT TRACED ALONG RAMP



MSS156-72-C, F3 L2 R18 (CLEAR) 0.5K. PANELS, ETC. ON RAMP (06/15/72)

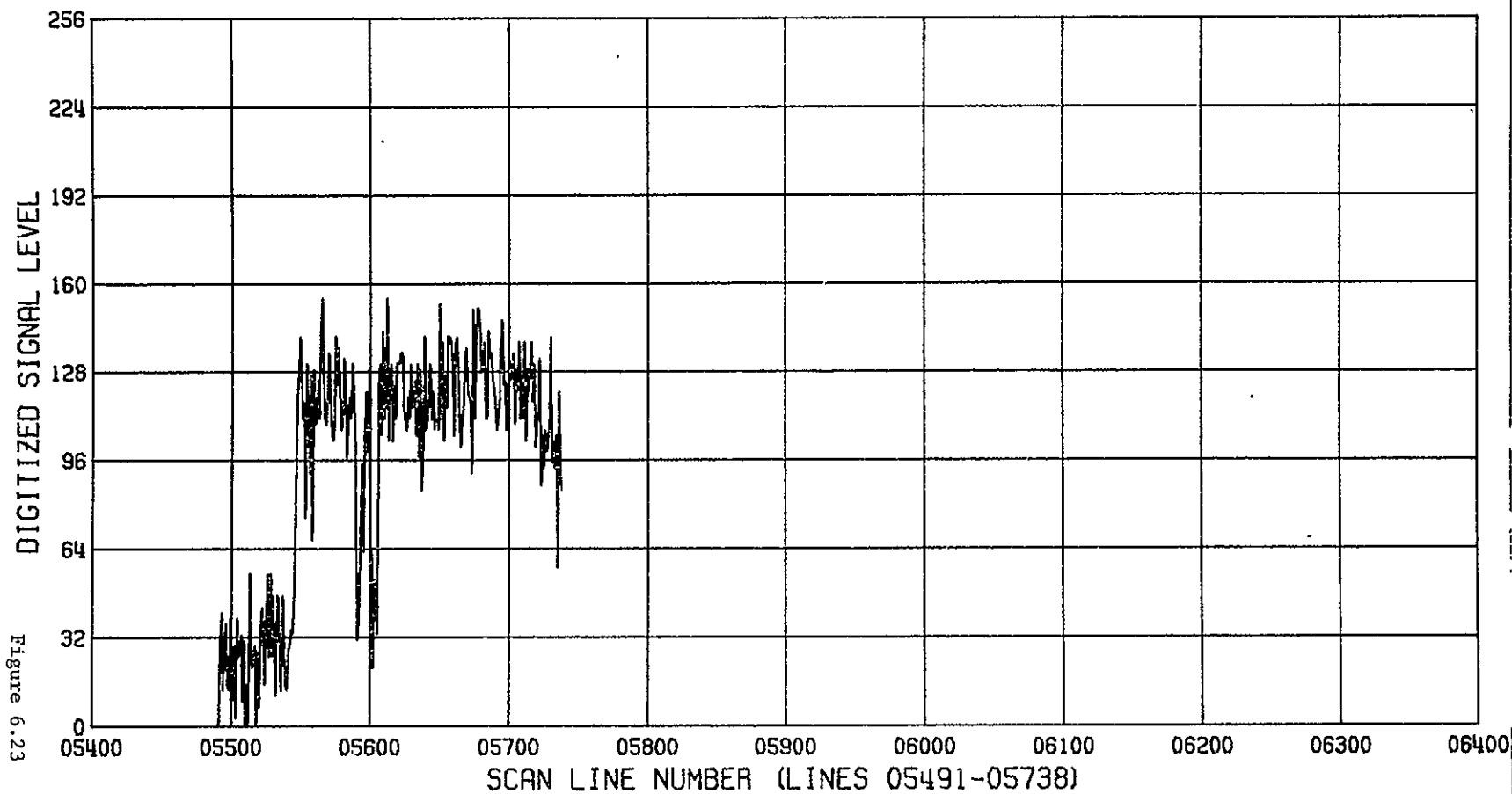
V/M=0.178 LOW TEMP=-11.1°C $\Delta T=38.6^{\circ}\text{C}$ FILTER SELECT=1 3.557/SEC/ELEMENT

SEGMENT 1 OF 1

CHANNEL 3: CAL 2, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 19:58:06 SEP 12, 1972 *
(SMALLPLOT, VERSION 2.0, P.F. LAMBECK)
PLOT ELEMENT 358, ALL LINES

SINGLE ELEMENT TRACED ALONG RAMP



HSS1514-72-8, F2 L2 B2 (COVERCAST) 14, 7K, PANELS, ETC. ON RAMP (06/15/72)
 06/02/72 16140409.5, RADAR ALI 08820 FT, TRUE HEADING 190.0°, DRIFT -07.6°
 V/H=0.0387 LON TEMP=10.9°C $\Delta T=36.3^{\circ}\text{C}$ FILTER SELECT=1 21.2214 SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 13: CAL 2, SCALE= 1X, OFFSET=1

NOISE BURSTS?

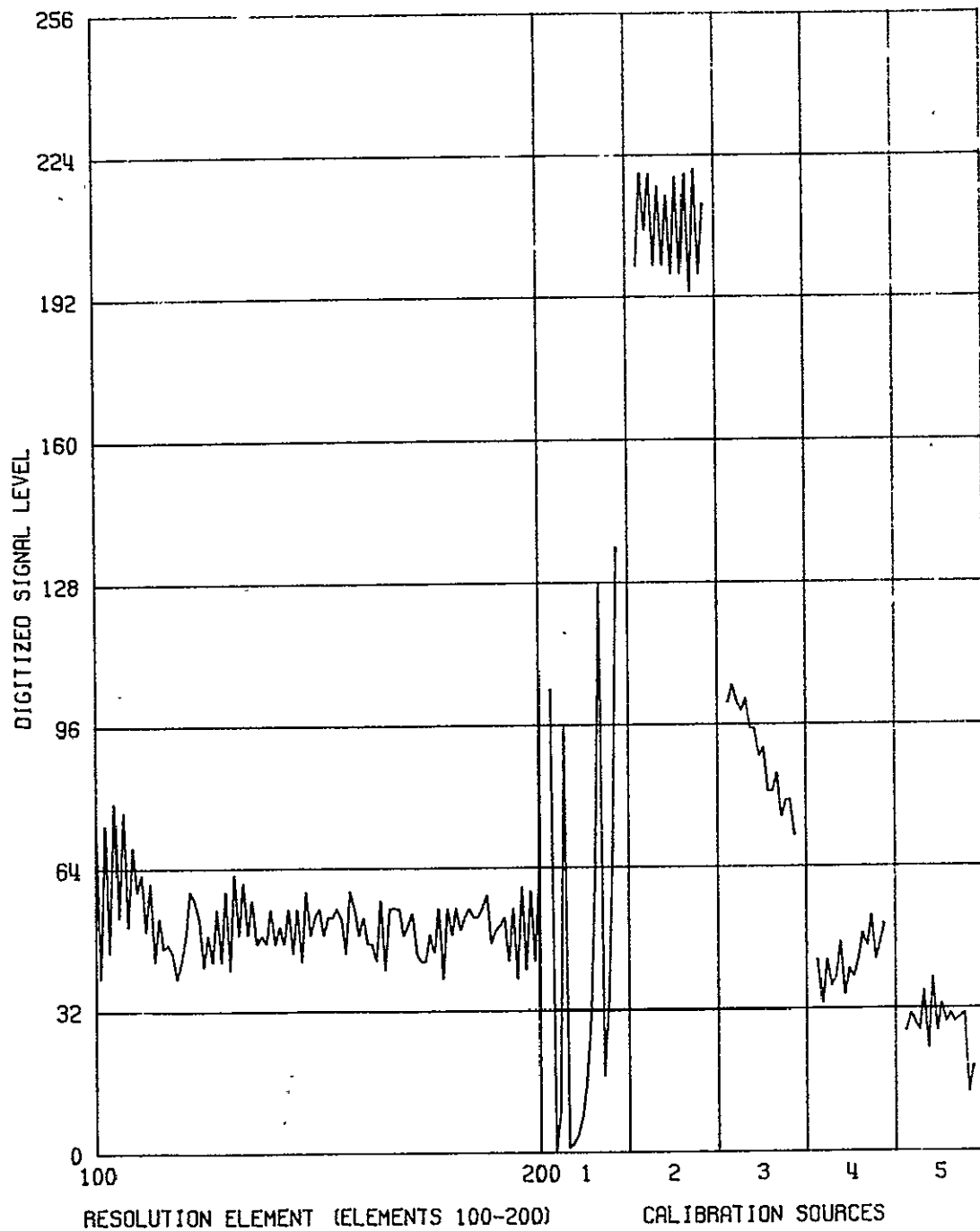


Figure 6.24

NSS154-72-8, F2 L2 R2 (OVERCAST) 14, 7K, PANELS, ETC. ON RAMP 06/15/72)
 06/02/72 16:40:08.5, INDIAN 6LT 08820 FT, TRUE HEADING 180.0°, DRIFFT -07.6°
 V/H=0.0367 LON TEMP=+10.8°C $\Delta T=36.3^\circ\text{C}$ FILTER SELECT=1 21.2214SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 141 CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 18:31:36 SEP 12, 1972 *
 CLARGEPLUT, VERSION 2.0, P.F. LAMBECCO
 PLOT LINE 859, ELEMENTS 100-200, AND CAL SOURCES

NOISE BURSTS?

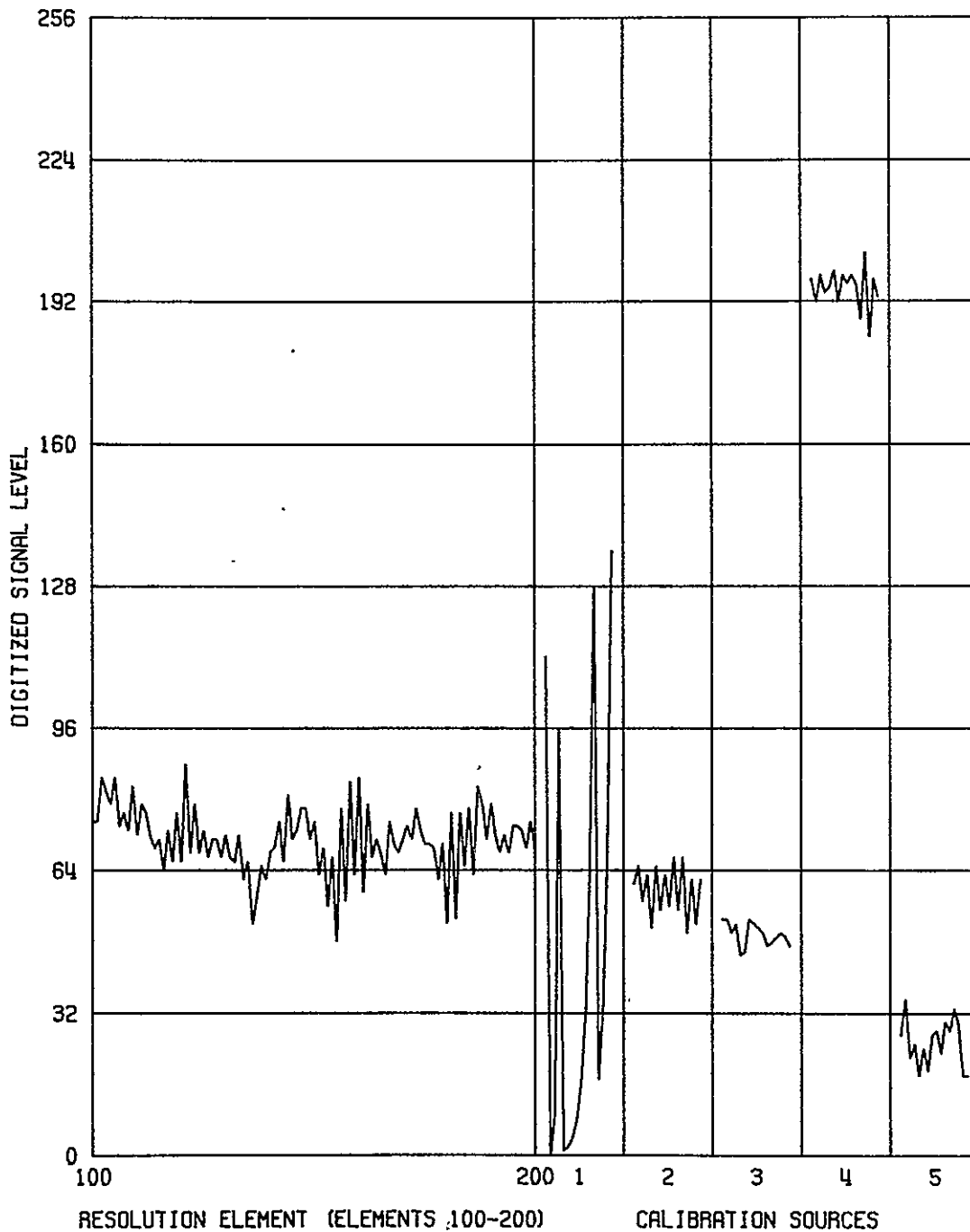


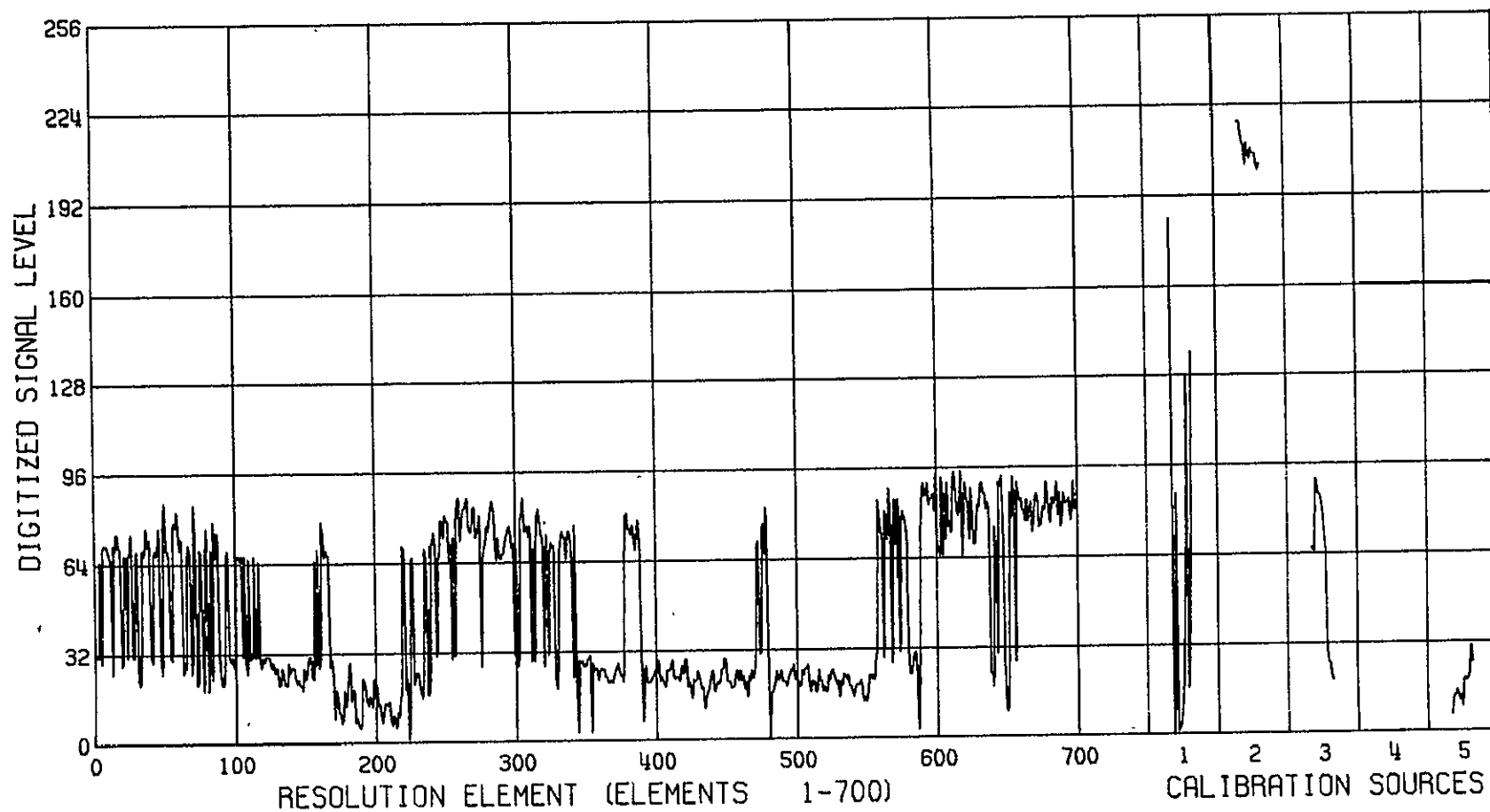
Figure 6.25

Figure 6.26

HSS156-72-B, F3 L2 R2 (CLEAR) 14.7K, BELLEVILLE LAKE (06/15/72)
06/04/72 15:37:41.4, RADAR ALT 14500-FT, TAWE HEADING -180.4°, DRAFT -08.0°
V/H=0.0287 LOW TEMP=10.8°C ΔT=36.2°C FILTER SELECT=1 27.679μSEC/ELEMENT
SEGMENT 1 OF 1
CHANNEL 23:- CAL 2, SCALE=1X, OFFSET=1

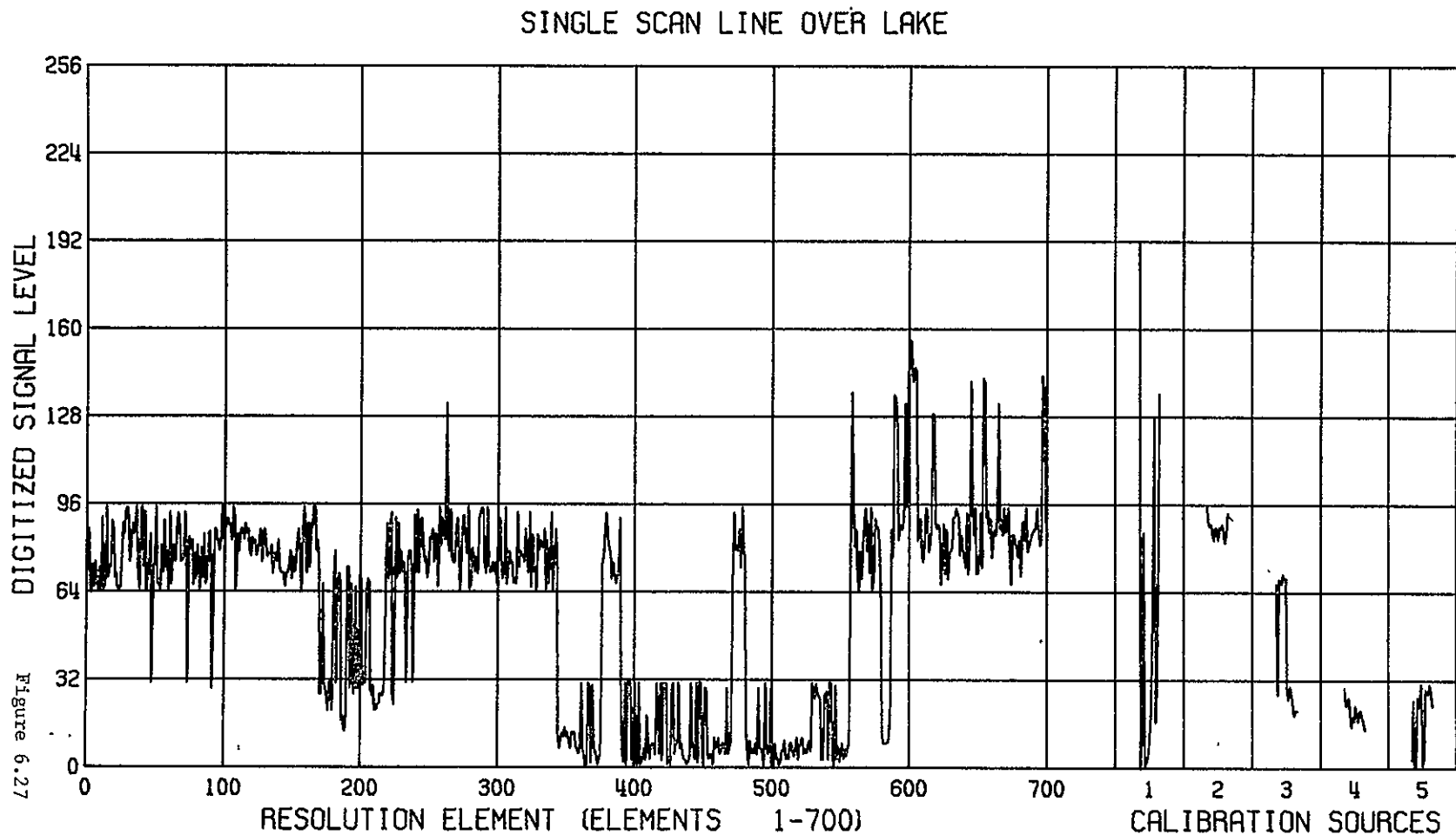
• ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 16:04:50 SEP 8, 1972 •
(SMALLPLOT, VERSION 2.0, P.F. LAMBECK)
PLOT LINE 1055, ALL ELEMENTS, AND CAL SOURCES

SINGLE SCAN LINE OVER LAKE



MSS156-72-B, F3 L2 R2 CLEAR 14.7K, BELLEVILLE LAKE 08/15/72)
 06/04/72 15:37:41.4, RADAR ALT 14500 FT, TRUE HEADING 100.4°, DRIFT -08.0°
 V/H=0.0287 LOW TEMP=10.8°C ΔT=36.2°C FILTER SELECT=1 27.678μSEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 24- CAL 2, SCALE= 1X, OFFSET=1

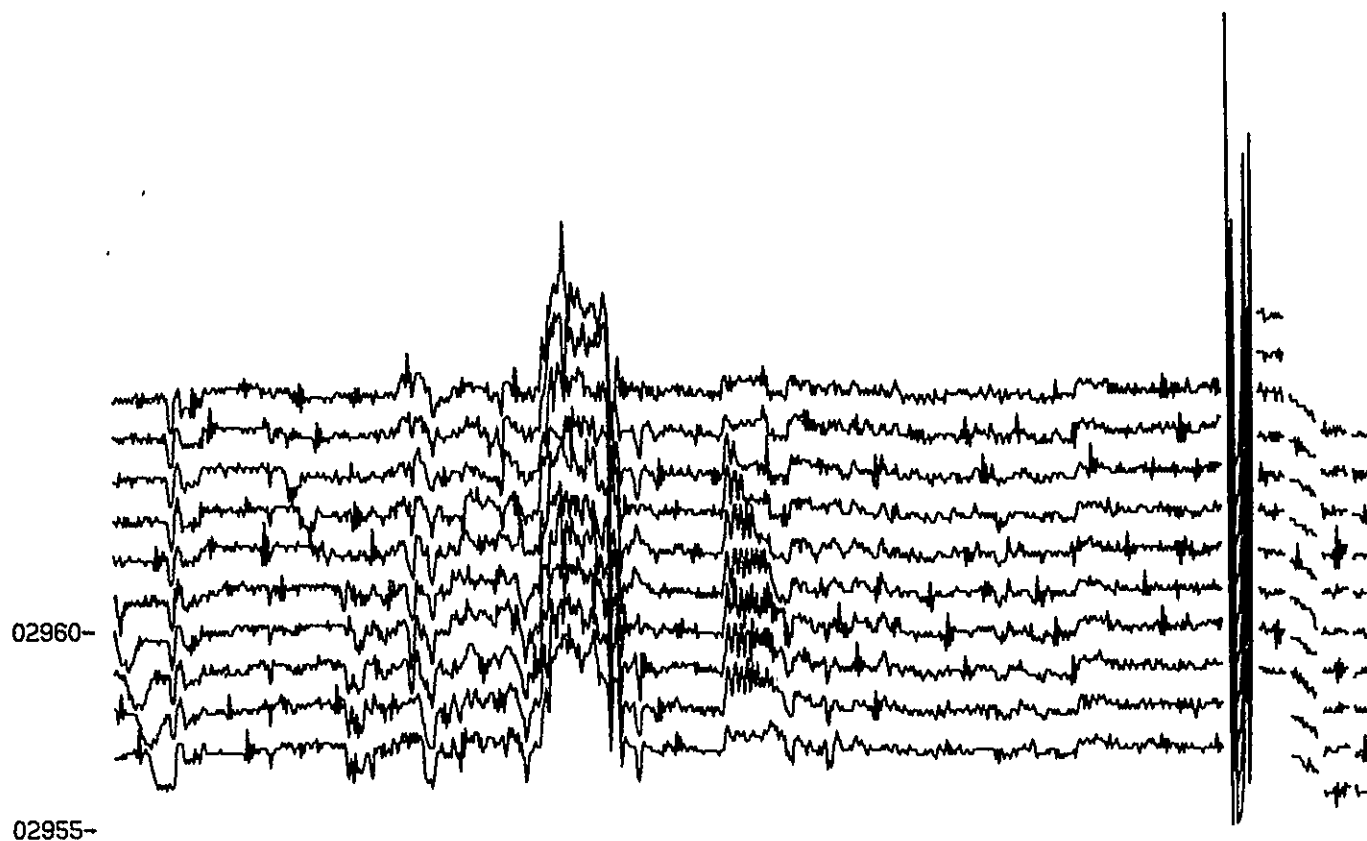
* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 16:04:50 SEP 8, 1972 *
 (SHALLOTT, VERSION 2.0, P.F. LANGELO)
 PLOT LINE LOSS, ALL ELEMENTS, AND CAL SOURCES



MS158-72-0, F3 L2 R13 (CLEAR) 1.7K, PANELS, ETC. ON RAMP (06/15/72)
06/04/72 17:03:12.1, RADAR ALT 01810 FT, TRUE HEADING 173.5°, DRIFT +03.2°
V/H-0.1887 LOW TEMP=-11.2°C $\Delta T=38.6^{\circ}\text{C}$ FILTER SELECT=1 3.8784SEC/ELEMENT
SEGMENT 1 OF 1
CHANNEL 23, CAL 2, SCALE=.25X, OFFSET=1
SCAN LINES 02955-02964, RESOLUTION ELEMENTS 1-700

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 23:03:34 SEP 11, 1972 *
IATRACE, VERSION 2.0, P.F. LAMBECK
1/4 INCH SPACING, 4 INCH MAX AMPLITUDE, 1 LINE X 1 ELEMENT AVERAGING
PLOT LINES 2855-2864, ALL ELEMENTS, AND CAL SOURCES

CONSECUTIVE A-TRACES SHOWING NOISE SPIKES



Monitoring of Scanner Temperatures and Calibration References

Figure 7.1 charts temperatures of arrays 3 and 4, as recorded in the tape edit housekeeping data, as a function of time for the flight of 4 June (2 June data, though limited, was consistent with this plot). Points marked in the plot correspond to values translated from the start ID housekeeping record for each tape edit we had obtained. Values from the stop ID records, some of which are evident in the plot for array 4, were plotted but were not marked. The tape edits were in general shorter than 2 seconds in real time. Array 2 data was clipped indicating less than -80.3°C . Available data for the interpretation of the housekeeping values did not go below -69°C for array 2 or below 23°K for array 4, hence values for these arrays were derived through extrapolation. Much of the array 4 data was clipped at 17°K , a lower temperature than might have been expected. The data indicates that the cooling of the arrays (as measured at the monitoring points) was adequate.

Figure 7.2 charts the current through the lamp filament used for calibration source 2, as recorded in the tape edit housekeeping data for the flight of 4 June. Only start ID values are marked; 2 June data was consistent with this plot. Over one third of this data was clipped at 8.107 amps. The current exhibits a maximum uncertainty of plus or minus .8 percent which, according to tests performed in the past on quartz-iodine lamps at The University of Michigan, would correspond to maximum uncertainties in radiance ranging from plus or minus 8 percent in the ultraviolet (channel 1) to plus or minus 2 percent in the near-infrared (channel 11). Better lamp current stabilization would be desirable from a standpoint of absolute calibration.

Figure 7.3 charts the temperature of the low temperature blackbody reference and the temperature difference between the two blackbody references (ΔT) both as indicated in the tape edit housekeeping data (start ID values marked) and as recorded from the operator's console into the flight log for 4 June (2 June data was similar). Data for ΔT from run 14 is not included in this plot since an operator error (failure to change the ΔT control range when ΔT was reduced by a factor of 2) caused the housekeeping data for ΔT during that run to be meaningless. Note the consistent discrepancies of 1 degree or more between the housekeeping values and the flight log values for these calibration parameters. It is not known which of these values indicate the true temperatures of the thermal references; however, both indicate that stabilization of these references is probably adequate.

Figures 7.4 and 7.5 chart the tape edit housekeeping data for the six temperature monitors located in and around the scanner, together with the temperature of the air outside the aircraft as indicated by channel 16 ($6.2\text{--}7.6\mu\text{m}$ - a water absorption band), for 4 June (2 June data was similar). Start ID housekeeping values are marked; trends in the variation of the altitude of the aircraft can be identified in the flight plan of Figure 1.4. Note that it took on the order of 15 to 30 minutes for the

interior of the scanner to reestablish equilibrium with the aircraft surroundings after the jump from 1.7 thousand feet to 14.7 thousand feet which occurred around 15:30 GMT (compare channel 16 data to various temperature monitors). During run 14 (4 June) both the start ID and stop ID data for the first three temperature monitors was disrupted (17:12:30 GMT - Figure 7.4). The source of this disruption is not known. During run 20 another disruption occurred affecting all six temperature monitors (18:17:30 GMT - Figures 7.4 and 7.5). The abnormally high noise in channel 16 indicated for run 23 (18:44:56 GMT - Figure 7.5) was due to a low frequency noise ripple (or drift) in that channel during that run. Note that the data for the P.M. tube support (physically mounted on the baseplate but exposed to the air inside the optics compartment) indicates that the air temperature of the optics compartment was adequately controlled (Figure 7.4).

TEMPERATURES OF ARRAYS #3 AND #4 TRANSLATED FROM HOUSEKEEPING DATA
(ARRAY #2 TEMPERATURE DATA WAS CLIPPED INDICATING LESS THAN -80.3°C)

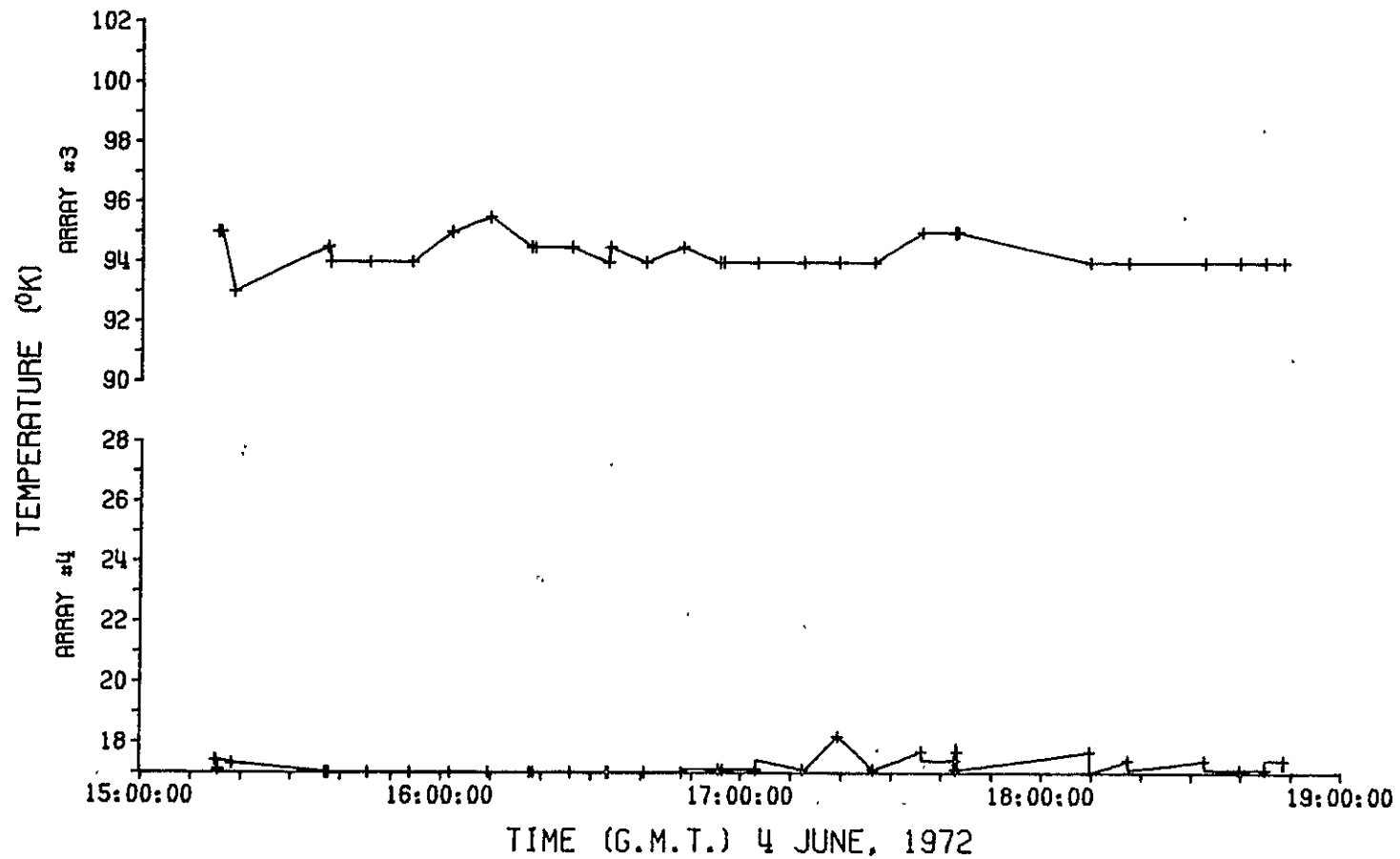
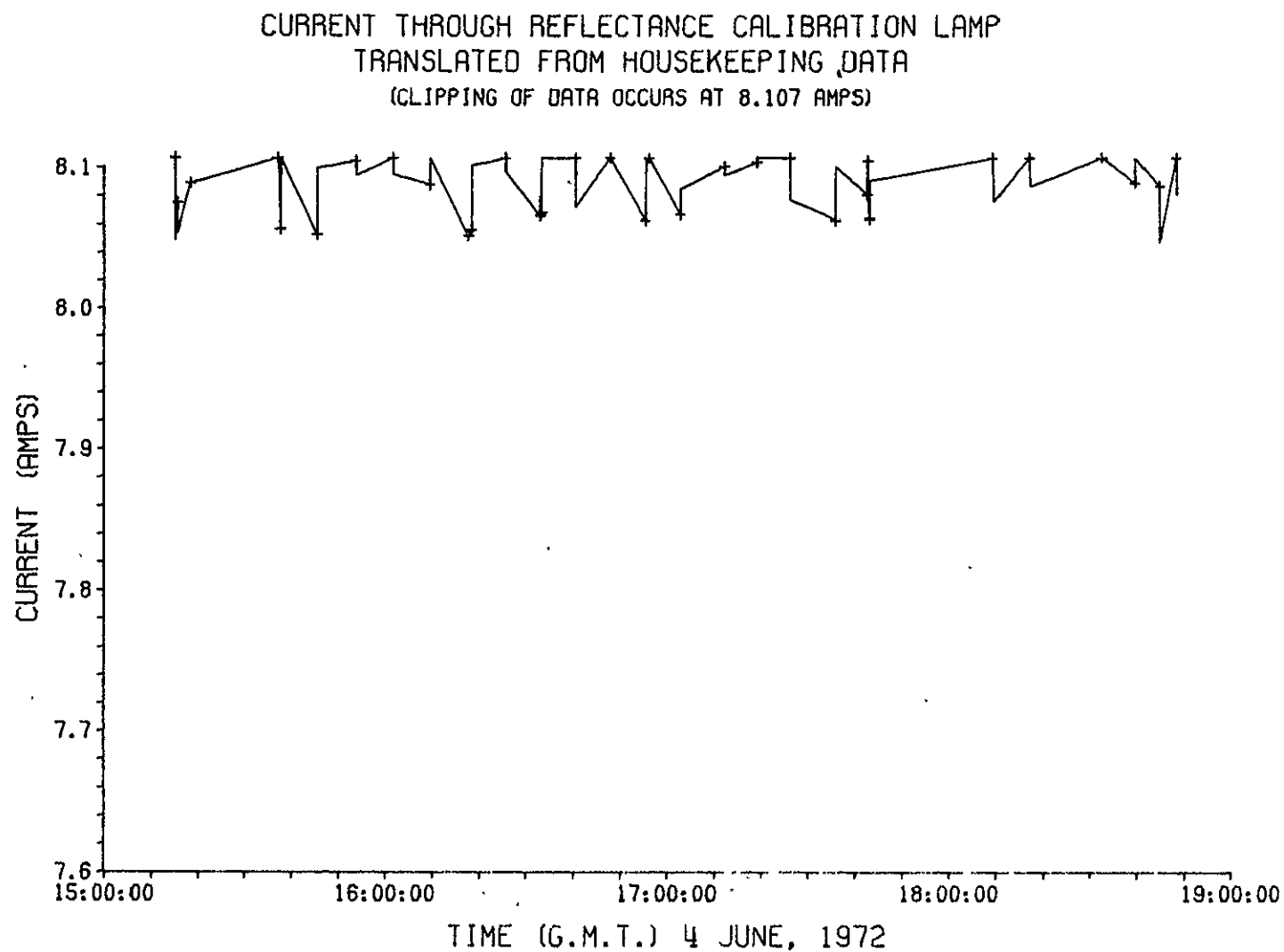


Figure 7.1

Figure 7.2

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 23:20:06 OCT 30, 1972
(DRAWPLOT, VERSION 1.0, P.F. LAMBECK)



LOW TEMPERATURE BLACKBODY AND ΔT DATA
(VALUES TRANSLATED FROM HOUSEKEEPING DATA MARKED WITH '+'S)
(VALUES READ FROM FLIGHT LOG SHEETS UNMARKED)

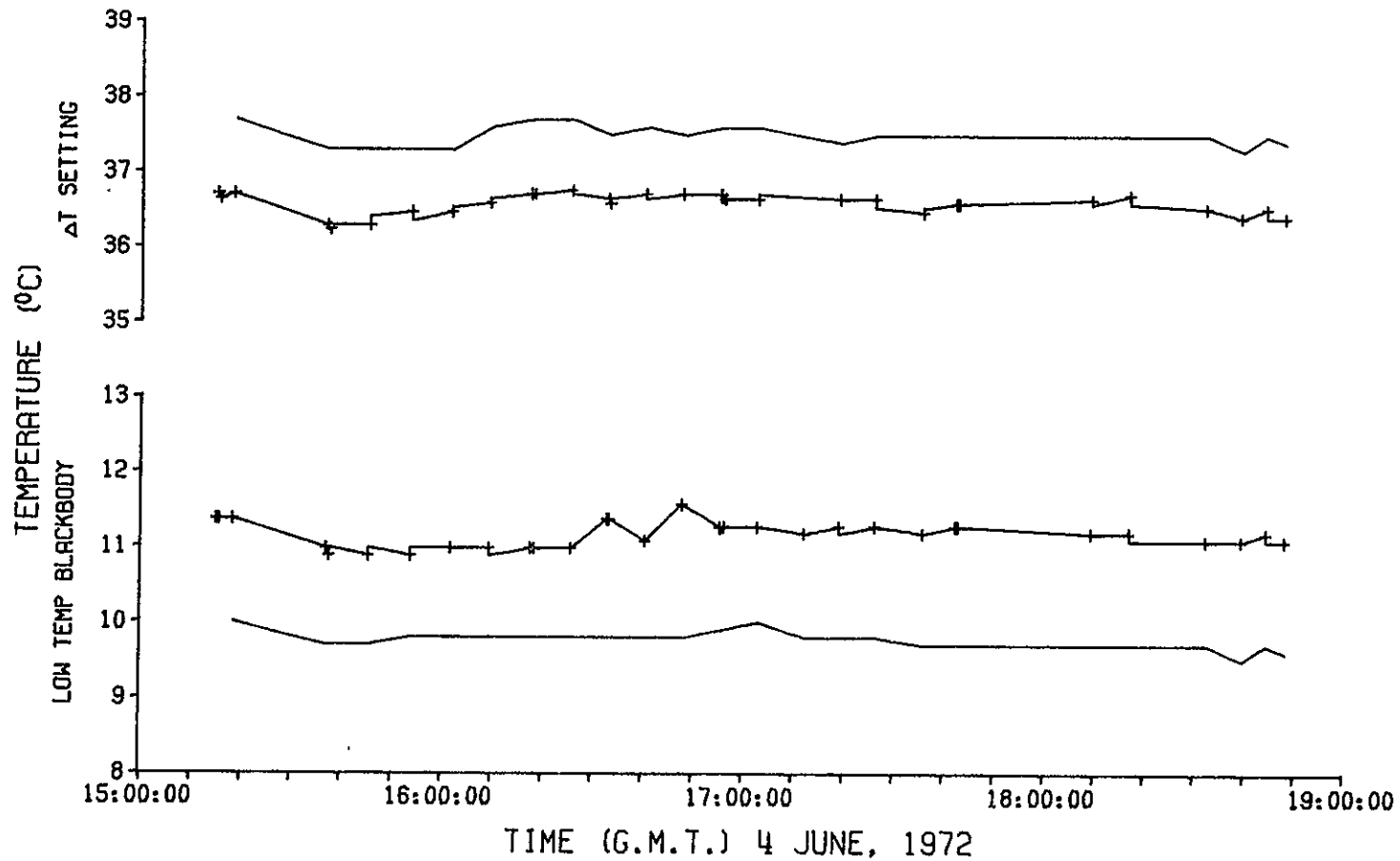


Figure 7.3

Figure 7.4

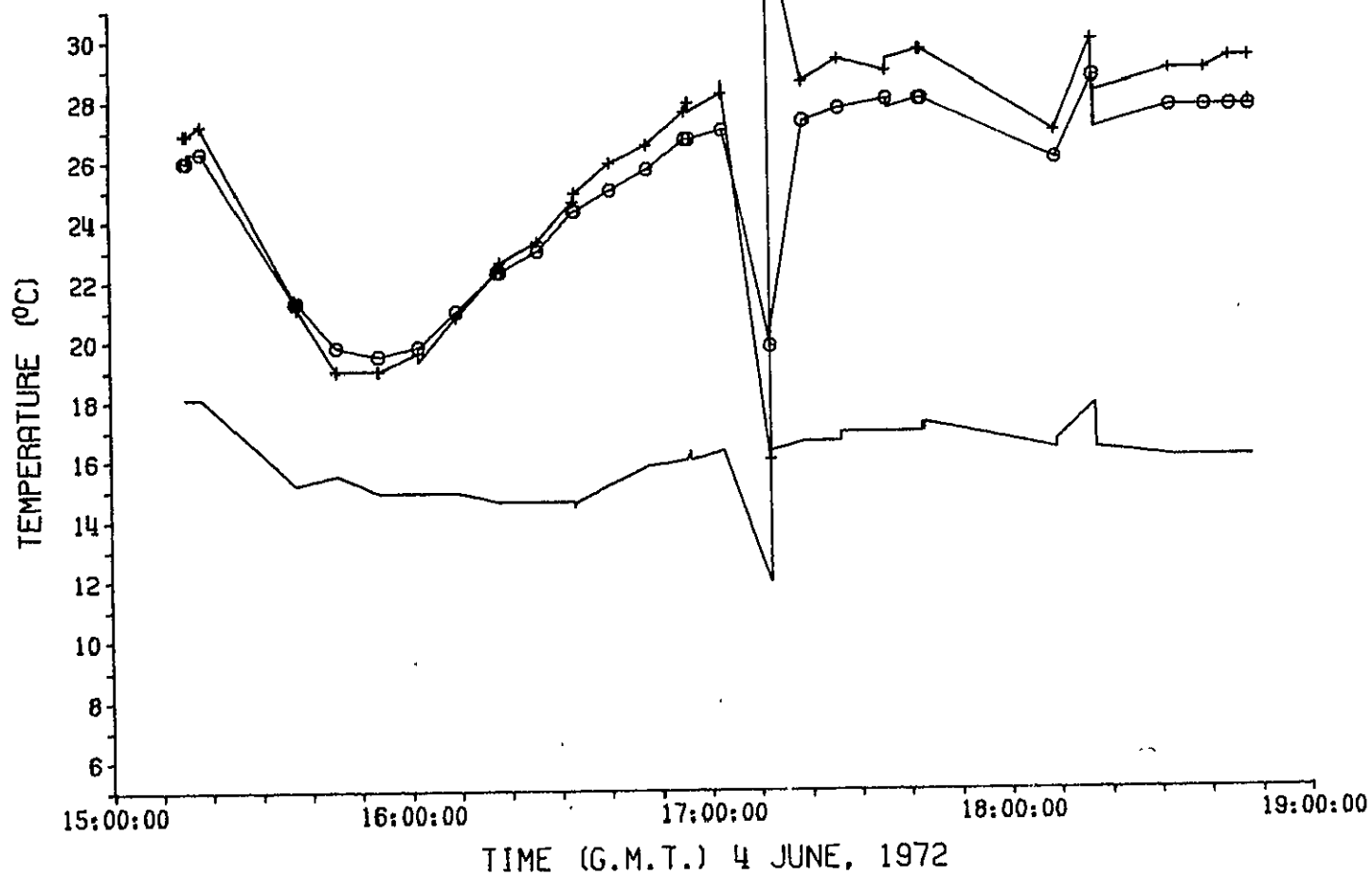
* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 23:20:37 OCT 30, 1972 *
 (GRAPHLOT, VERSION 1.0, P.F. LAMBECK)

TEMPERATURES AT UV/VIS WINDOW, AIR INLET, AND P.M. TUBE SUPPORT TRANSLATED FROM HOUSEKEEPING DATA

(UV/VIS WINDOW DATA MARKED WITH '+'S)

(AIR INLET DATA MARKED WITH 'o'S)

(P.M. TUBE SUPPORT DATA UNMARKED)



TEMPERATURES AT MOTOR SHROUD, AFT BULKHEAD, AND BASEPLATE
TRANSLATED FROM HOUSEKEEPING DATA
AND INDICATED TEMPERATURE FROM CHANNEL 16 (6.2 μ M-7.6 μ M)
(MOTOR SHROUD DATA MARKED WITH + 'S) (AFT BULKHEAD DATA MARKED WITH o 'S)
(BASEPLATE DATA MARKED WITH • 'S) (CHANNEL 16 DATA UNMARKED - NOISE LIMITS DOTTED)

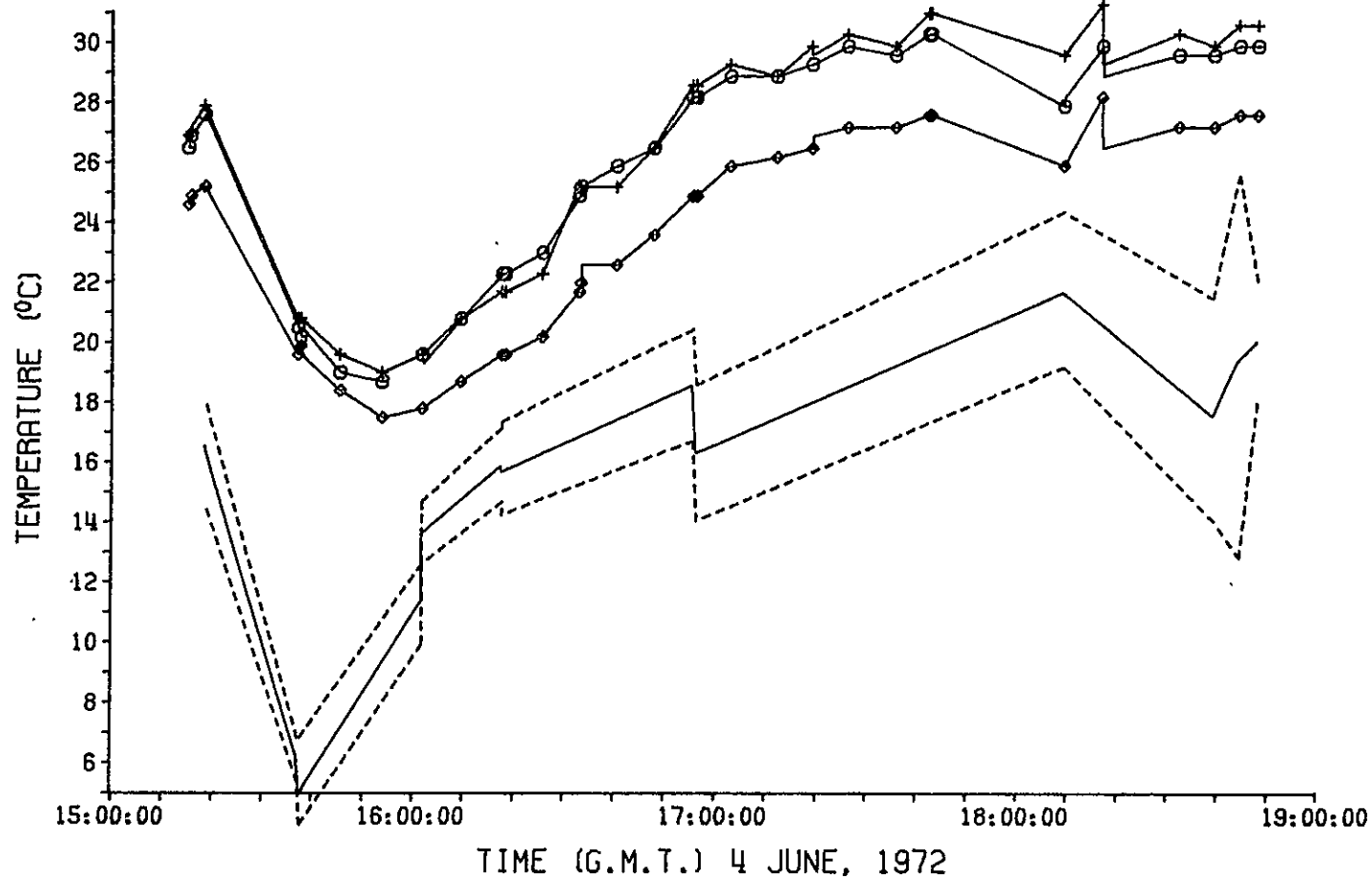


Figure 7.5

Gain and Offset Drift

MSDS signal gain and offset is controlled by clamping a high and a low level calibration source signal in each channel to separate voltage levels, usually between zero and 5 volts. These clamping voltages are set up prior to flight (generally) using screwdriver adjustments. Those adjustments requested for the 2 June and 4 June flights are listed at the bottom of Figure 1.4.

In some instances it was found that these screwdriver adjustments could not be made as we had requested, in which case an adjustment as close as possible to our requested level was made. In particular, in channel 3 the clamping level for the low calibration source could barely be brought up high enough to fall within the dynamic range for that channel, consequently this calibration reference was occasionally observed to be clipped at the low end of the dynamic range for channel 3. In channel 16, while this low clamping level could be placed within the lower part of the dynamic range, it could not be raised as high as was requested and consequently, at the highest flight altitude, data for channel 16 was partially clipped at the low end of the dynamic range. Some problems were also encountered in setting the clamping levels for channel 6.

The reaction time for the clamping circuitry is supposed to be slow enough so that noise should not cause appreciable fluctuations in the clamping, thus a channel with low frequency noise should show the effect of this noise in its calibration source signal levels, each wavering up and down with the noise while clamping remains at an essentially fixed signal level.

In Figures 8.1-8.24, signal levels observed for the more important calibration sources in each channel are plotted for the flight of 4 June. All data points are marked for those calibration sources on which clamping is supposed to be performing. The sky radiance signal (on which no clamping was performed for any of the data in the plots) is plotted unmarked for correlation with the other calibration references in channels 1-13, 23 and 24 (the reflective channels). Dotted lines represent the requested clamping levels for the high and low level calibration references in each channel.

Note the apparent increase in sun and sky illumination indicated in channel 1 (ultraviolet) during the higher altitude runs (15:37:13 and 16:01:57 GMT, runs 2 and 5, 14.7 and 6.7 thousand feet - Figure 8.1). Channel 2 indicates a slight offset drift during these two runs (Figure 8.2), while channel 3 shows a substantial offset drift during the same two runs (Figure 8.3).

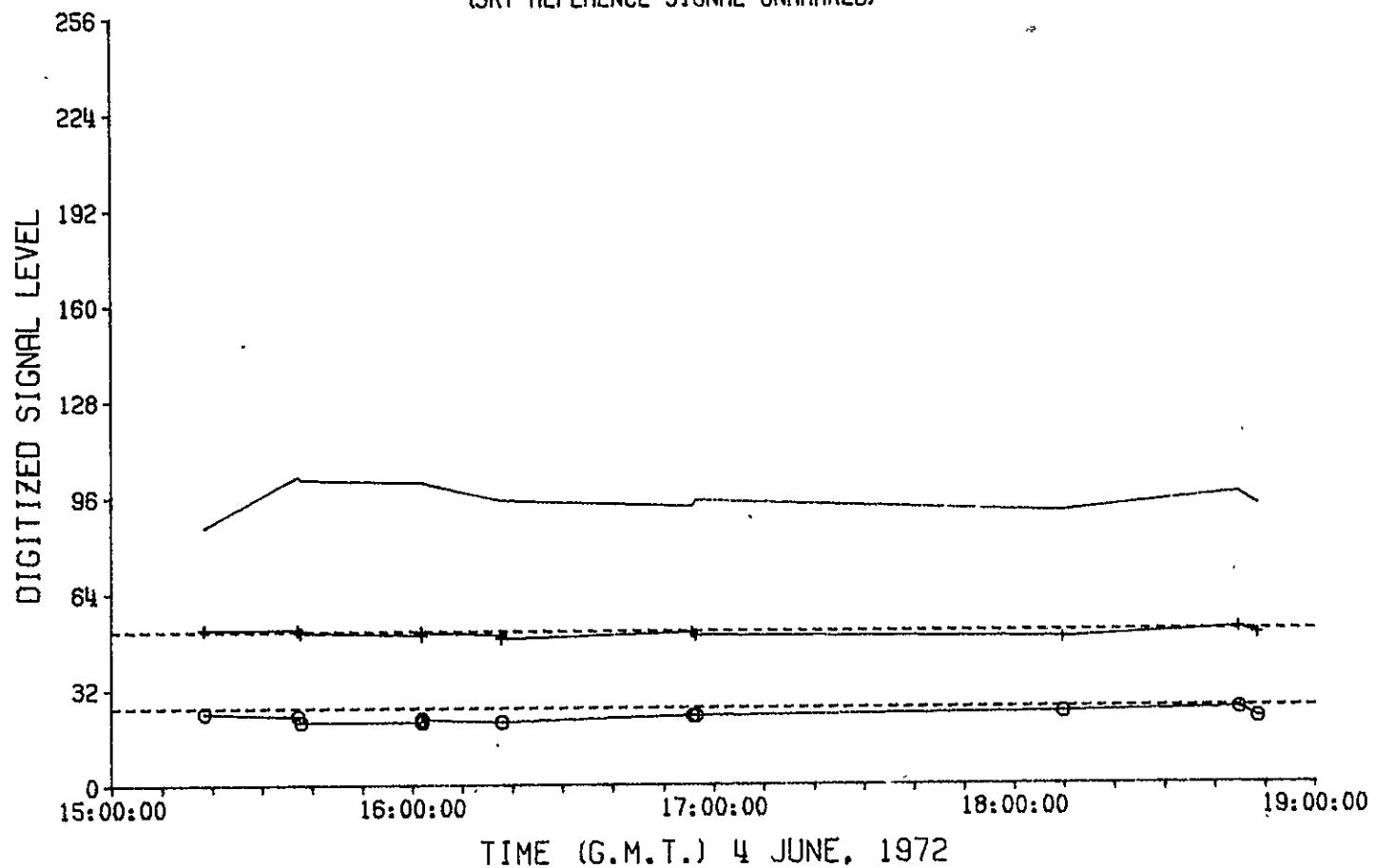
Channel 13 shows a sudden change in the level of the low calibration source between run 7 (16:17:56 GMT) and run 12 (16:55:51 GMT) which persisted throughout the remainder of the runs (Figure 8.13).

All other channels appeared to be more or less stable in both gain and offset throughout the flight, although it is somewhat debatable whether the low frequency variations seen in channels 15 and 16 are due to noise or drift.

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:42:30 NOV 1, 1972 "
DRAWPLOT, VERSION 1.0, P.F. LAMBECKO
+

Figure 8.1

CALIBRATION SOURCE VALUES FOR CHANNEL 1
(LAMP SIGNAL MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH o 'S - REQUESTED LEVEL DOTTED)
(SKY REFERENCE SIGNAL UNMARKED)



CALIBRATION SOURCE VALUES FOR CHANNEL 2
(LAMP SIGNAL MARKED WITH +'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O'S - REQUESTED LEVEL DOTTED)
(SKY REFERENCE SIGNAL UNMARKED)

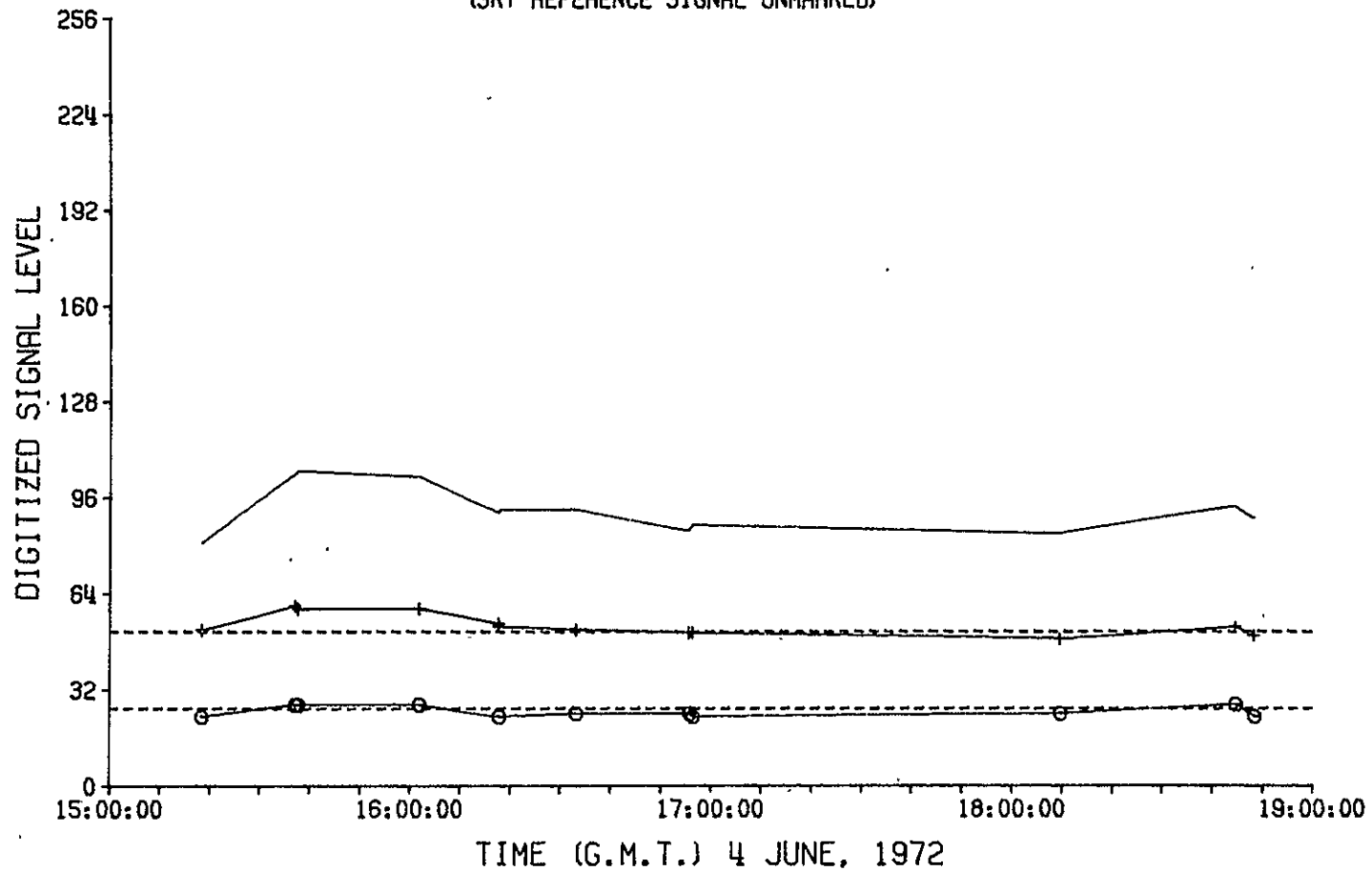
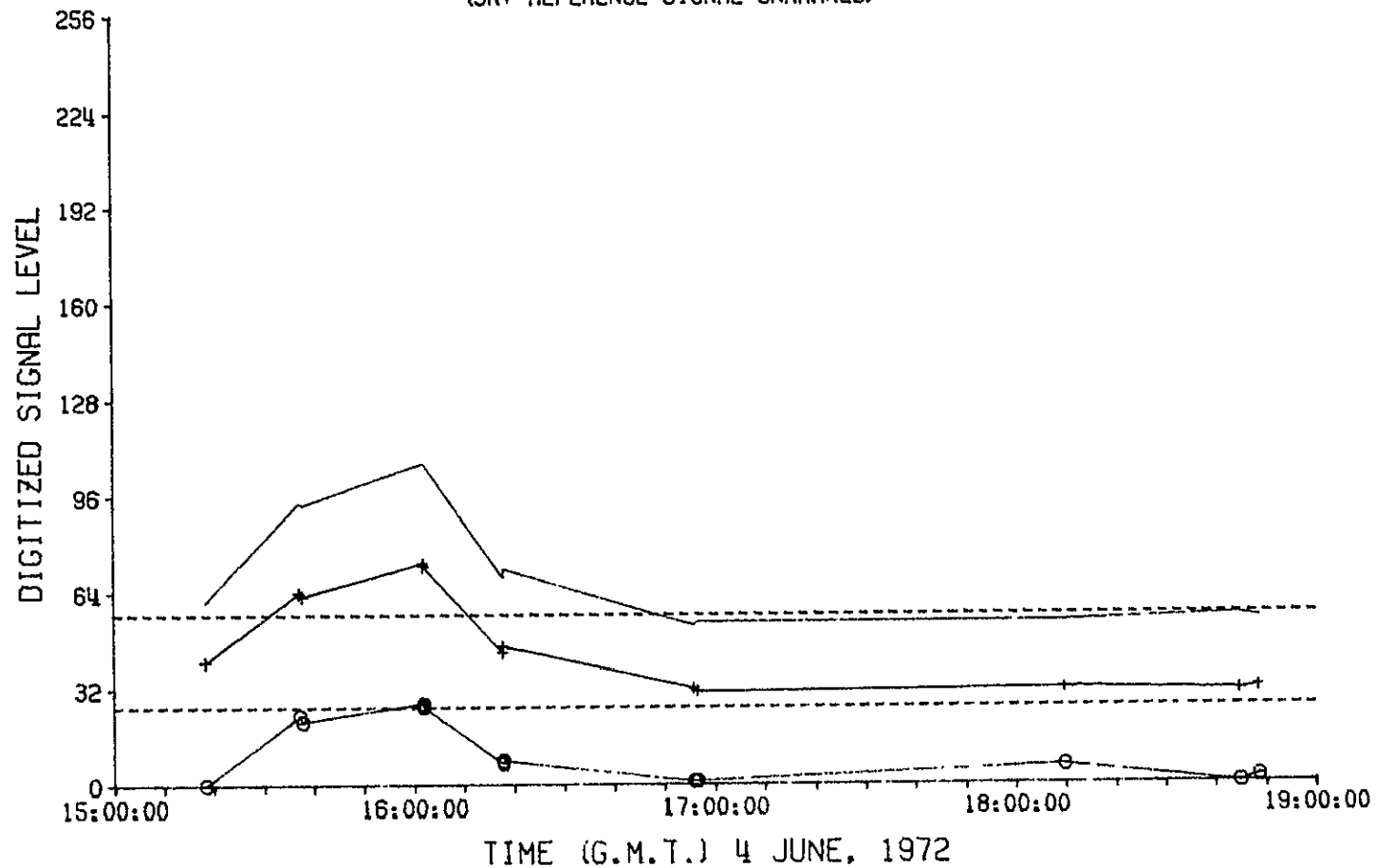


Figure 8.2

Figure 8.3

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:43:07 NOV 1, 1972 *
 * GRAMPLOT, VERSION 1.0, P.F. LAMBECK *

CALIBRATION SOURCE VALUES FOR CHANNEL 3
 (LAMP SIGNAL MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
 (LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)
 (SKY REFERENCE SIGNAL UNMARKED)



CALIBRATION SOURCE VALUES FOR CHANNEL 4
(LAMP SIGNAL MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH o 'S - REQUESTED LEVEL DOTTED)
(SKY REFERENCE SIGNAL UNMARKED)

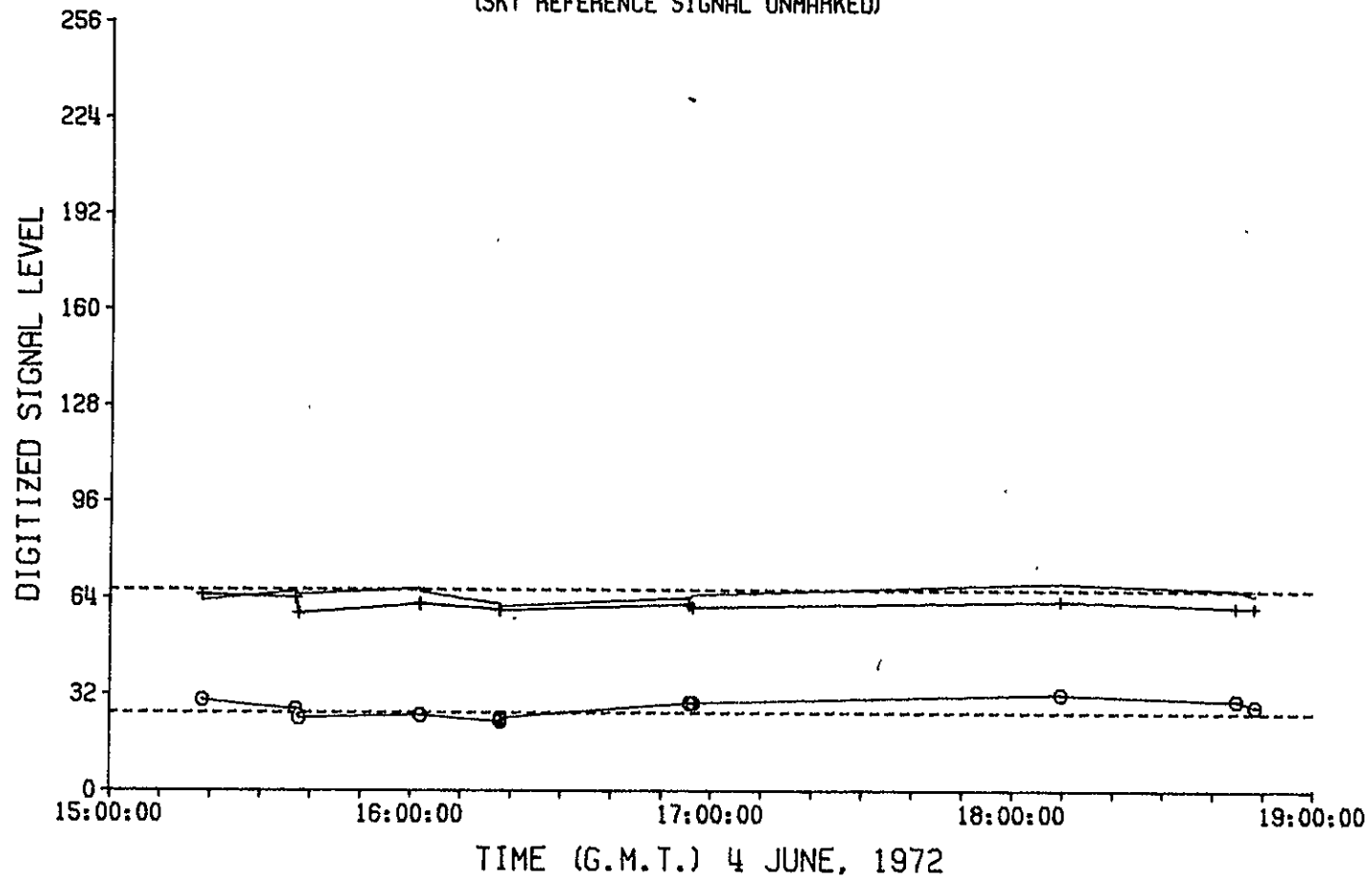
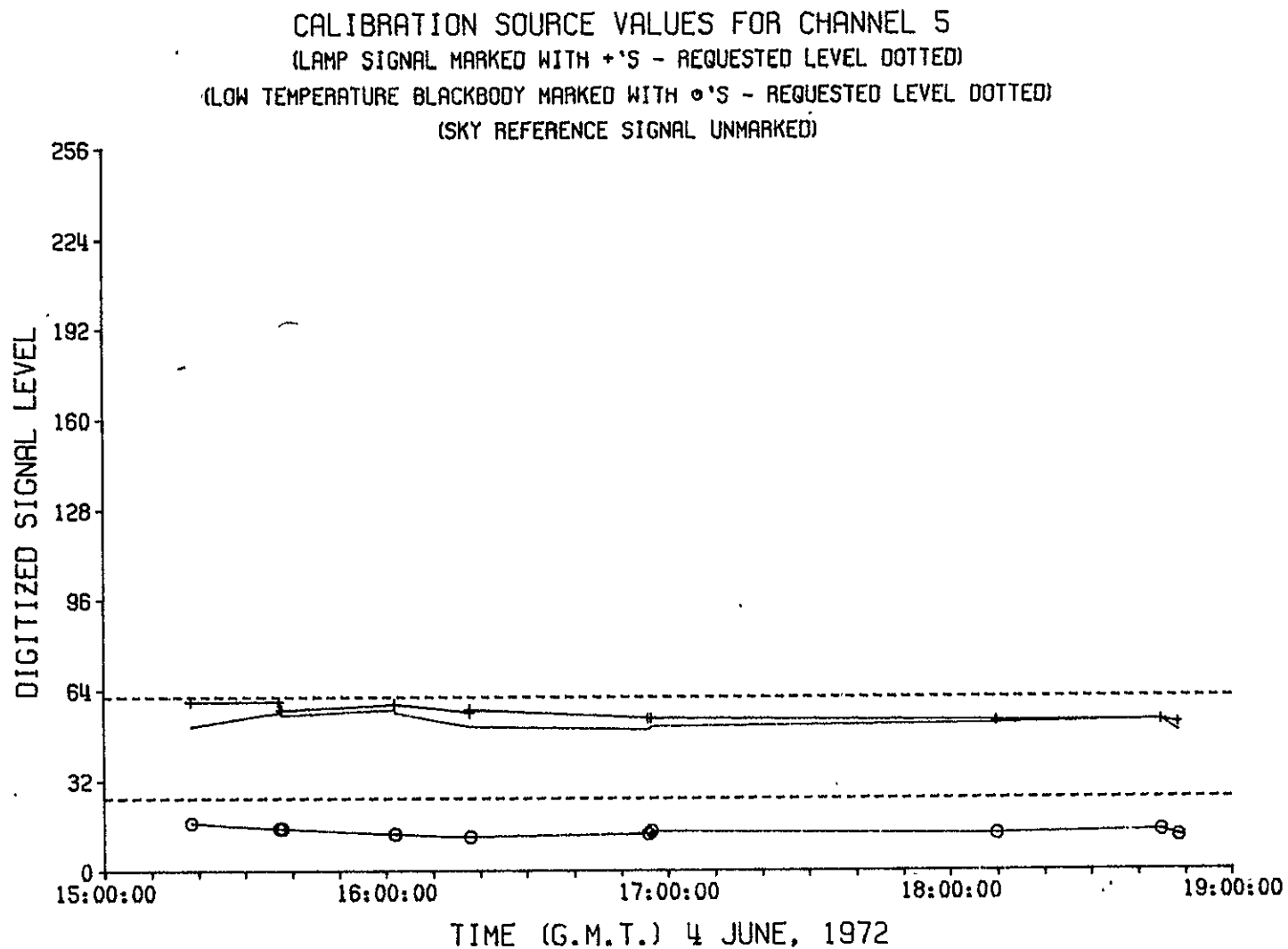


Figure 8.4

Figure 8.5

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:43:57 NOV 1, 1972 *
CORRAMPLOT, VERSION 1.0, P.F. LAMBECK



CALIBRATION SOURCE VALUES FOR CHANNEL 6
(LAMP SIGNAL MARKED WITH +'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O'S - REQUESTED LEVEL DOTTED)
(SKY REFERENCE SIGNAL UNMARKED)

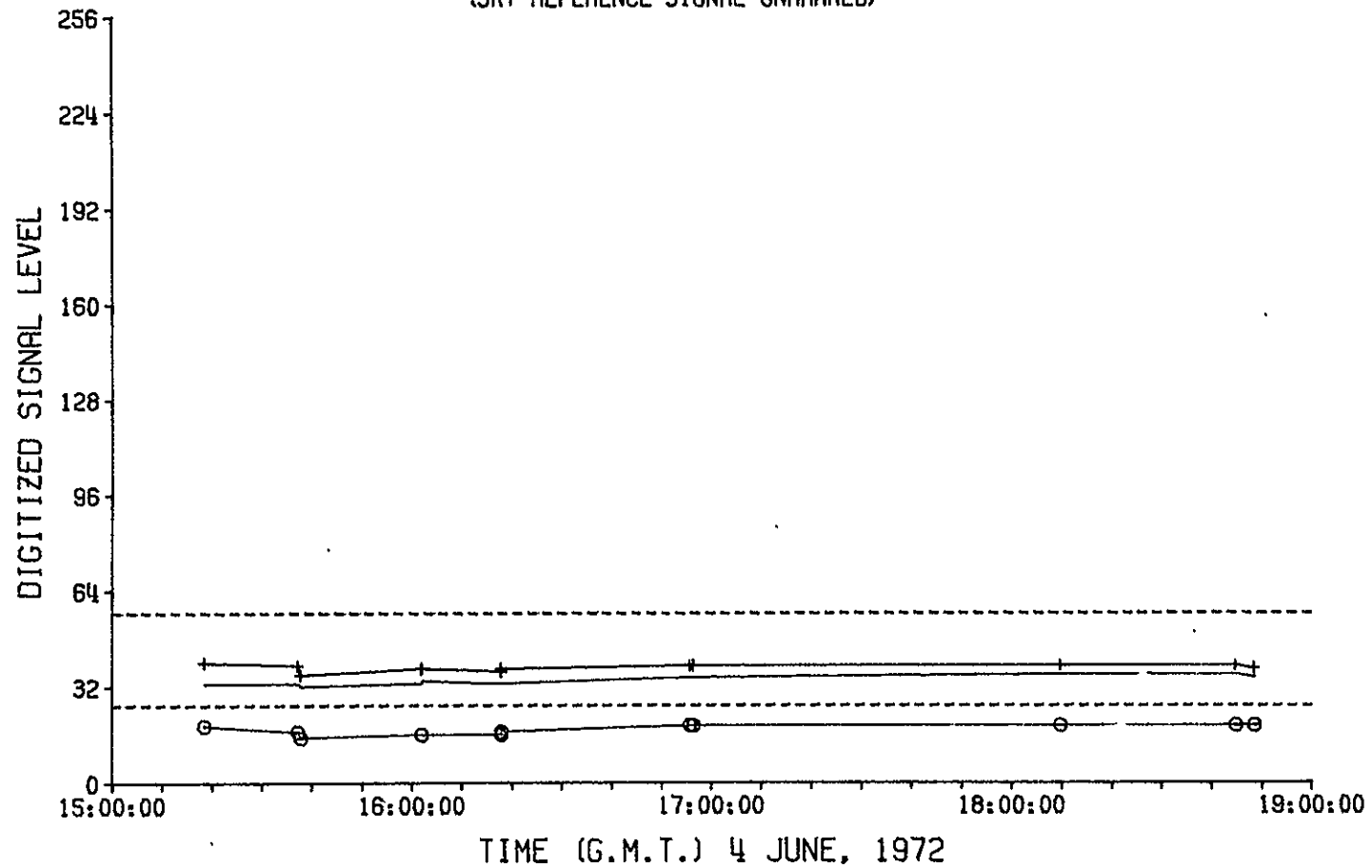
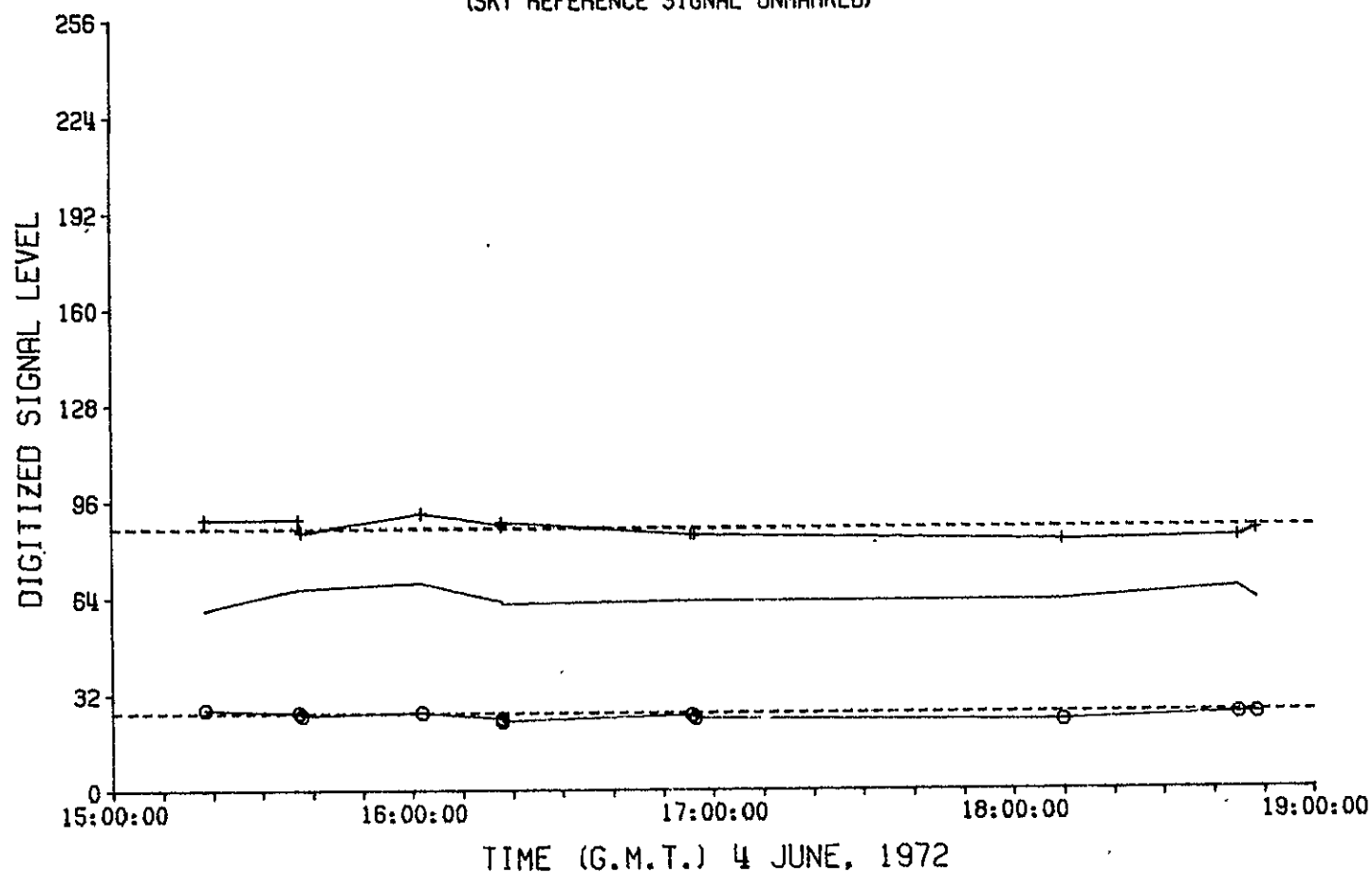


Figure 8.6

Figure 8.7

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:44:25 NOV 1. 1972
GRAMPLOT, VERSION 1.0, P.F. LANBECK

CALIBRATION SOURCE VALUES FOR CHANNEL 7
(LAMP SIGNAL MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)
(SKY REFERENCE SIGNAL UNMARKED)



CALIBRATION SOURCE VALUES FOR CHANNEL 8
(LAMP SIGNAL MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)
(SKY REFERENCE SIGNAL UNMARKED)

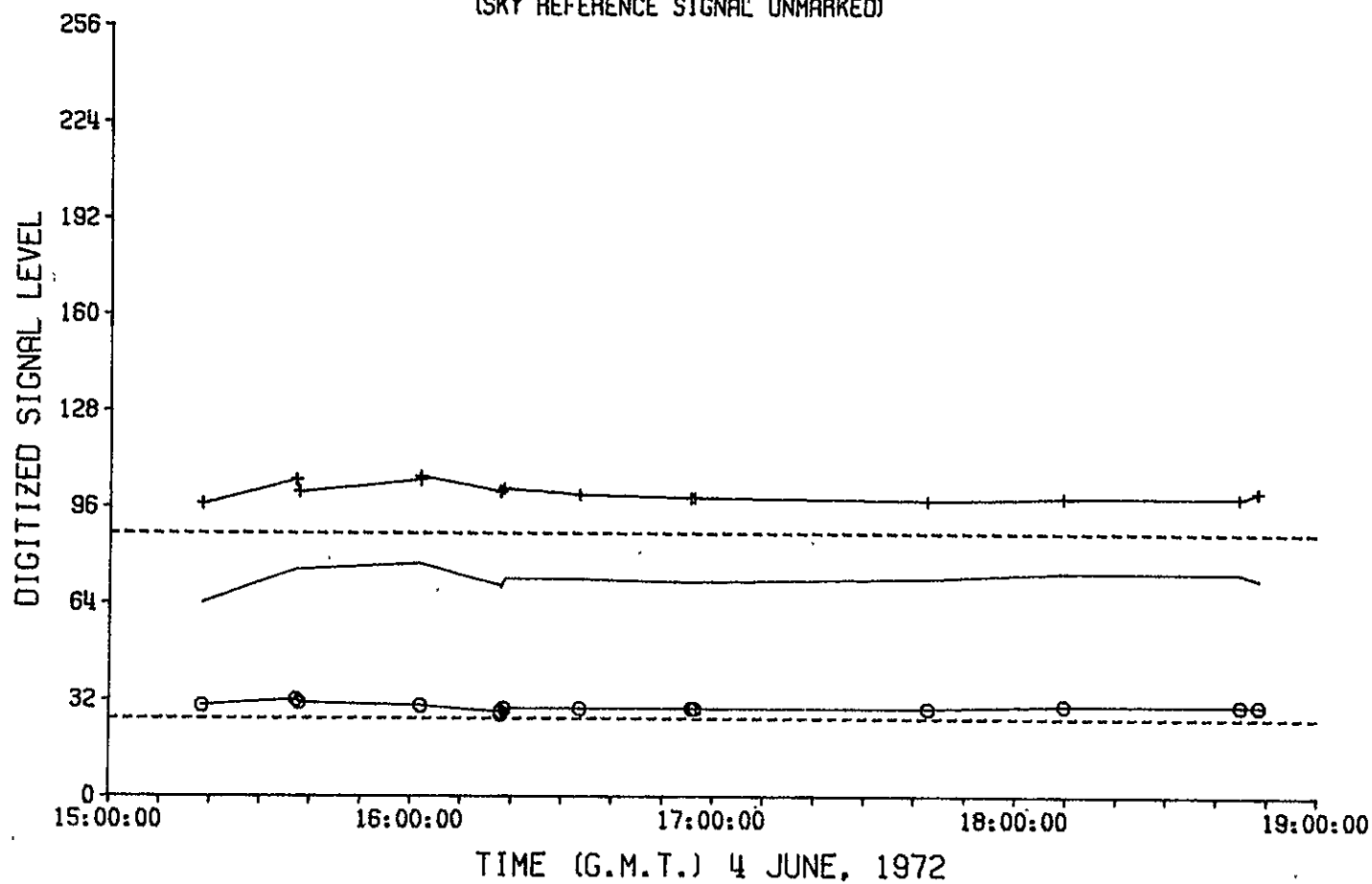
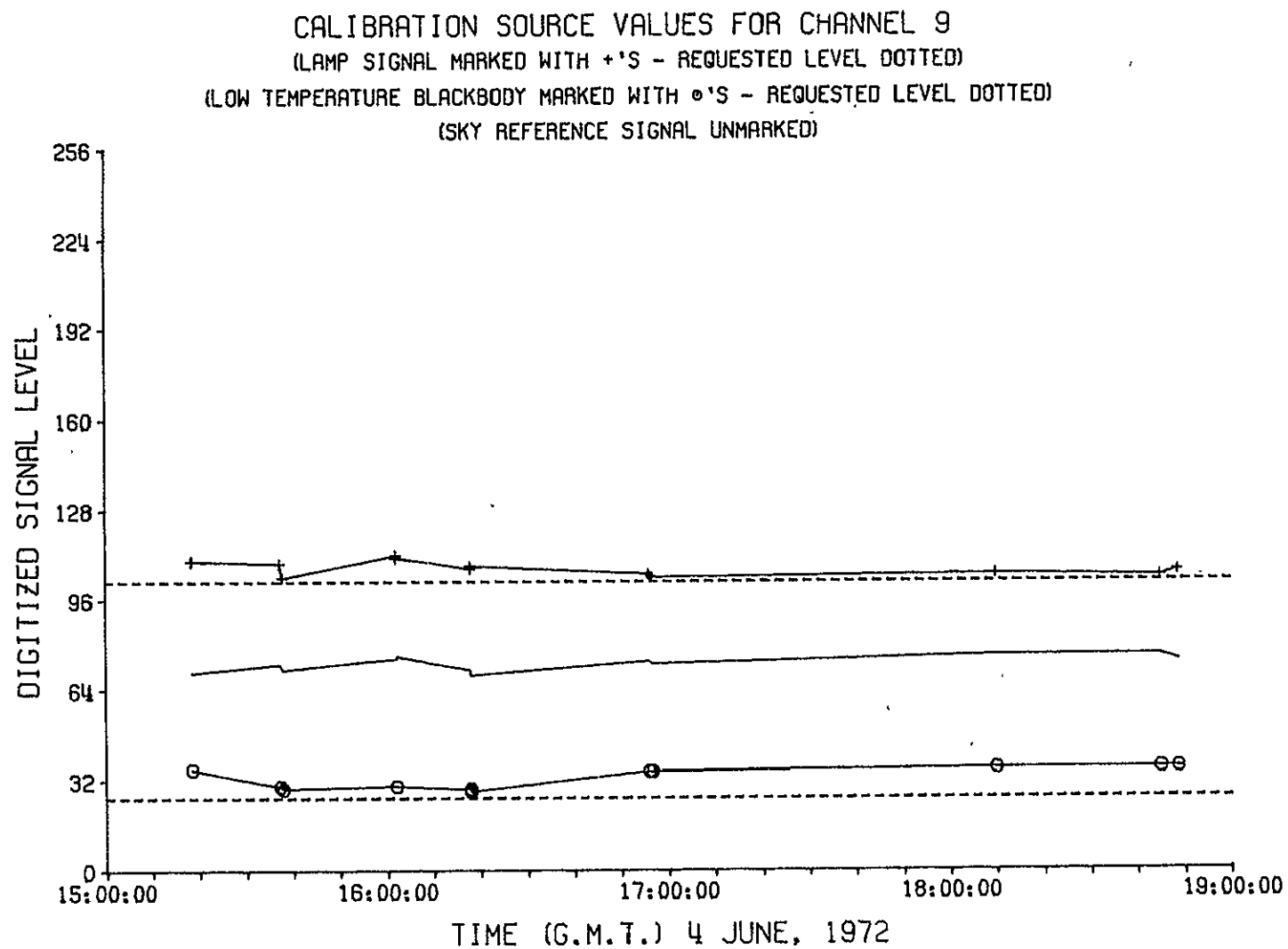


Figure 8.8

Figure 8.9

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:44:51 NOV 1, 1972 *
(ORAMLOT, VERSION 1.0, P.F. LAMBECK)



CALIBRATION SOURCE VALUES FOR CHANNEL 10
(LAMP SIGNAL MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)
(SKY REFERENCE SIGNAL UNMARKED)

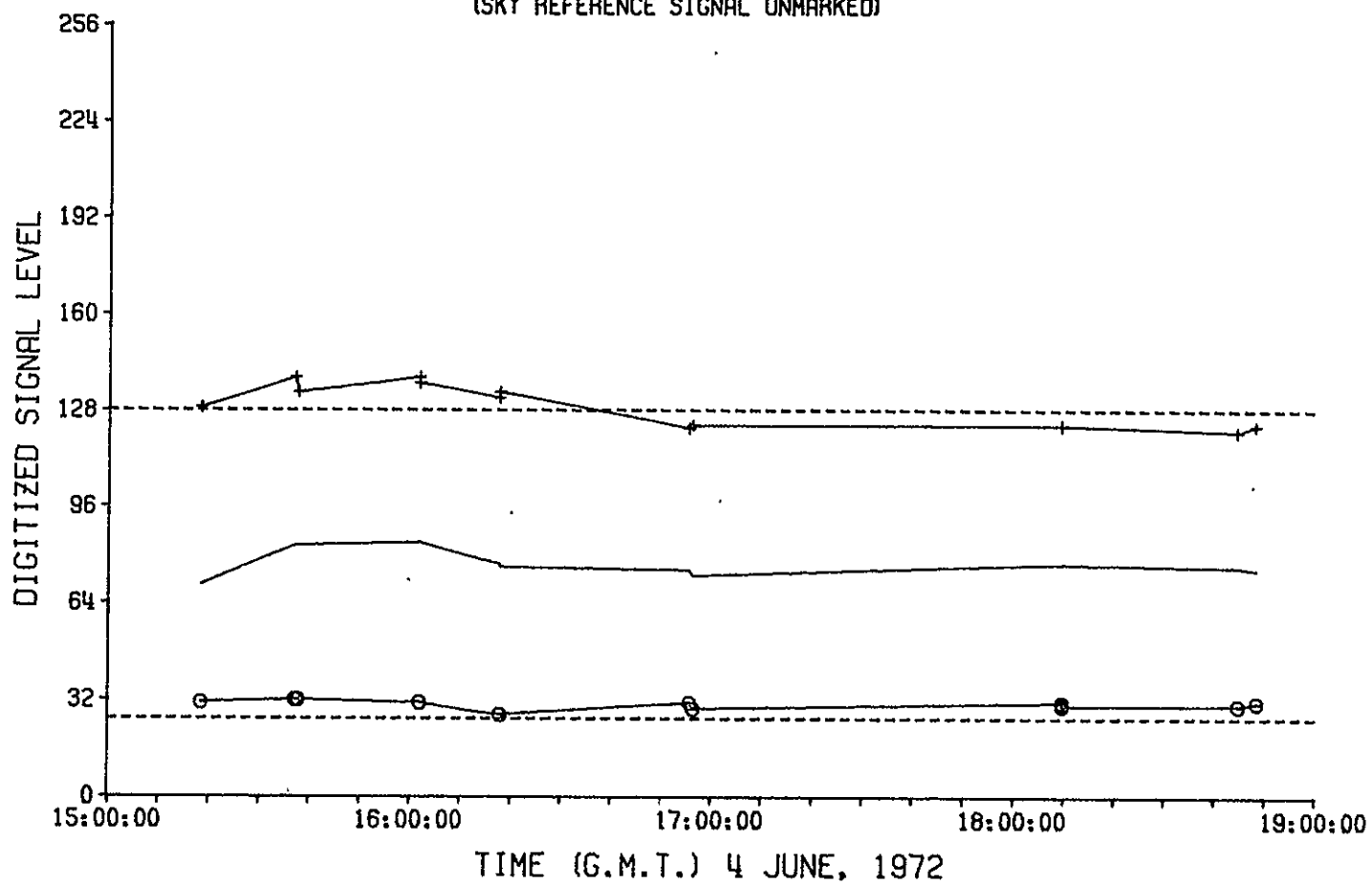
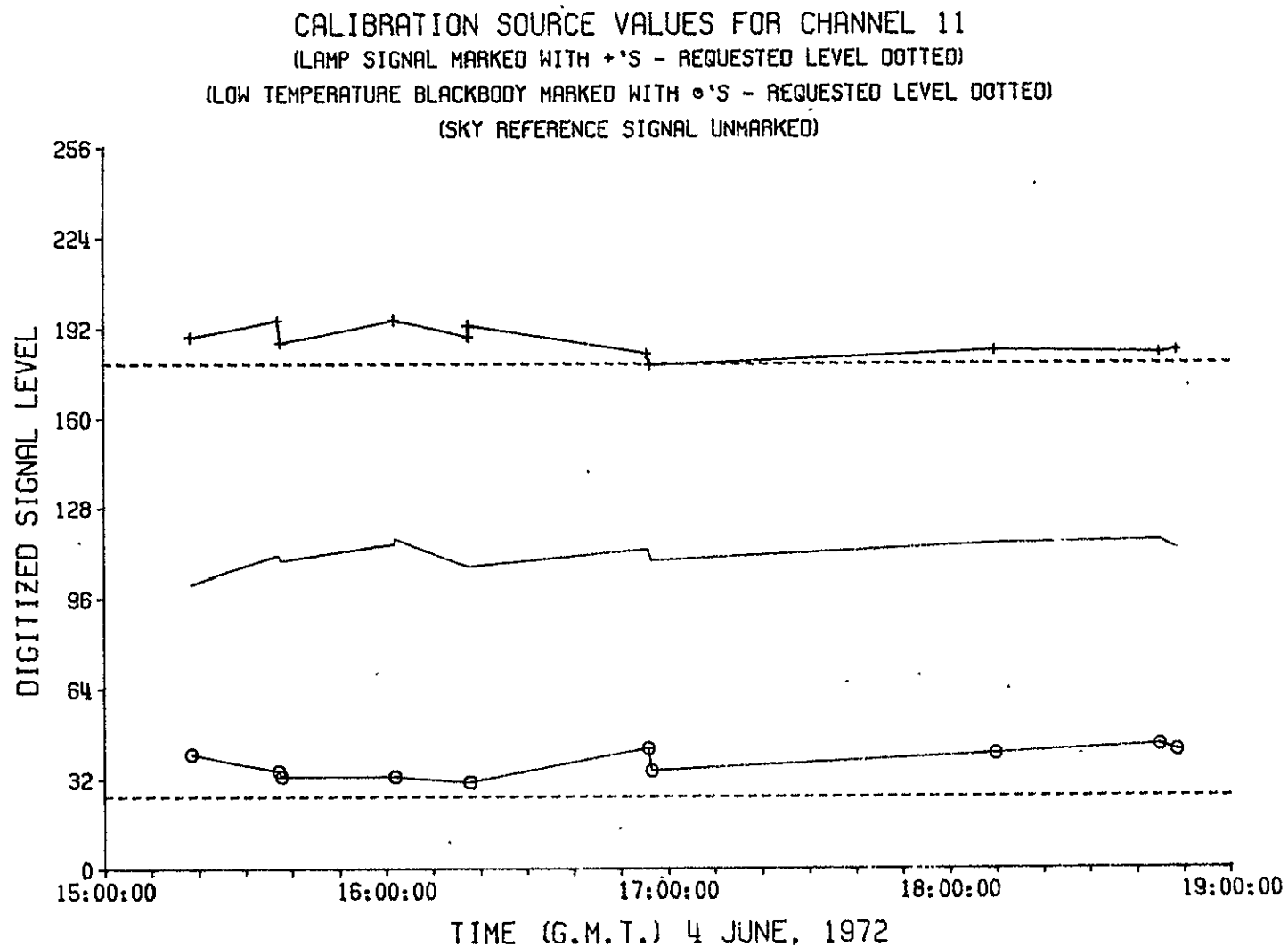


Figure 8.10

Figure 8.11

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:45:18 NOV 1, 1972 *
DRAWPLOT, VERSION 1.0, P.F. LANBECK



CALIBRATION SOURCE VALUES FOR CHANNEL 12
(LAMP SIGNAL MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)
(SKY REFERENCE SIGNAL UNMARKED)

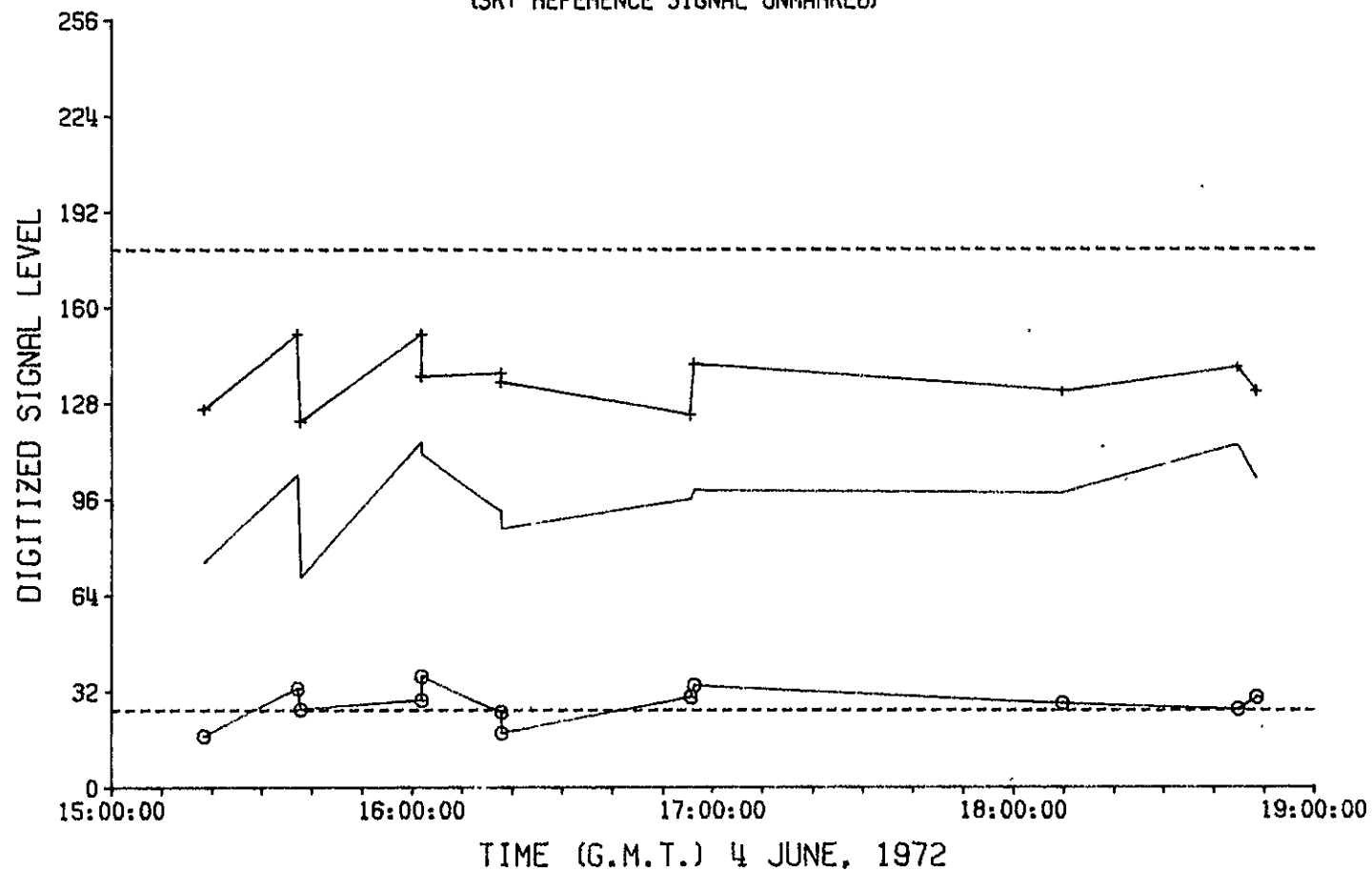
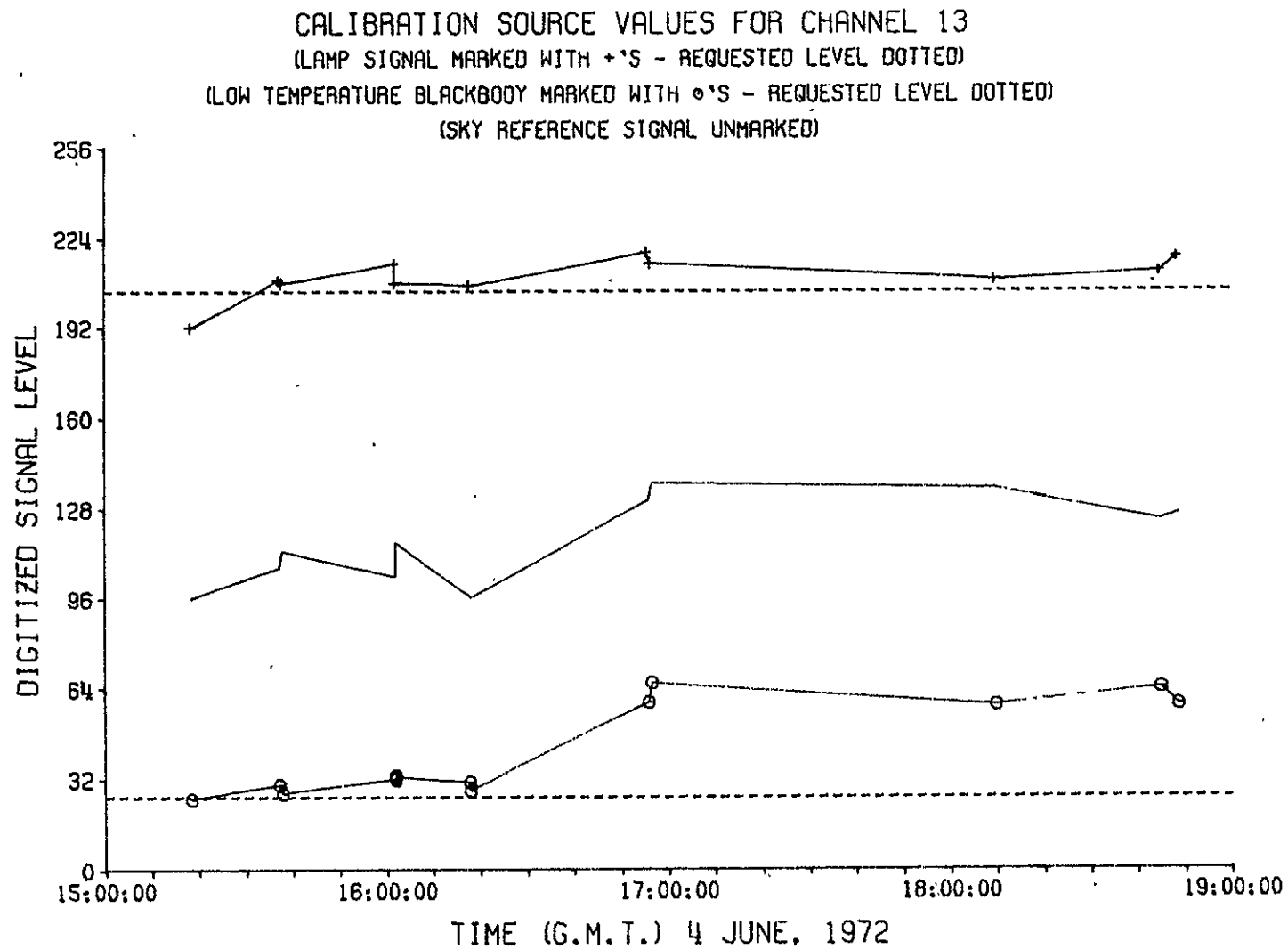


Figure 8.12

Figure 8.13

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:45:46 NOV 1, 1972 *
(DRAWPLOT, VERSION 1.0, P.F. LAMBECK)



CALIBRATION SOURCE VALUES FOR CHANNEL 14
(HIGH TEMPERATURE BLACKBODY MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)

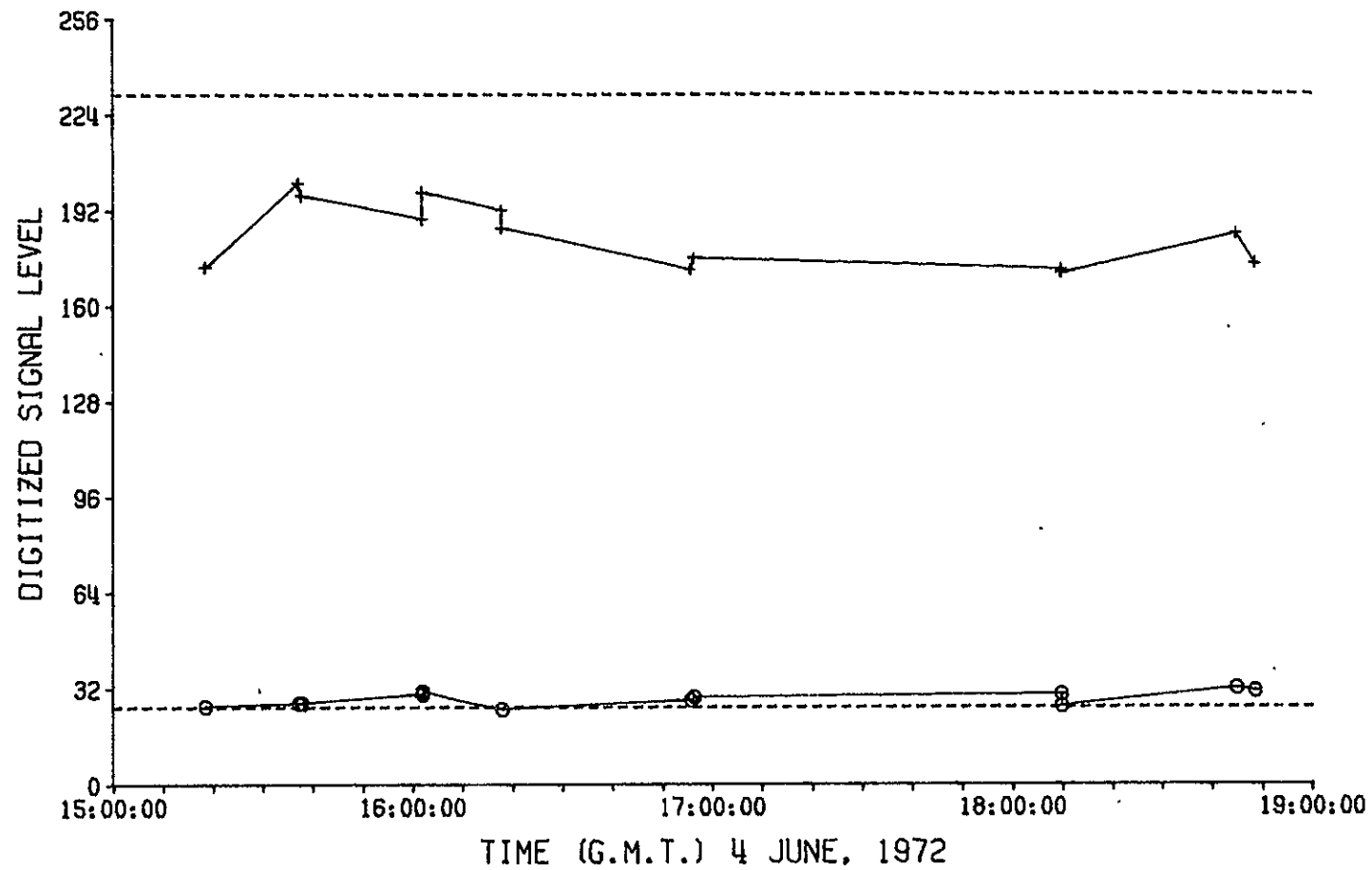
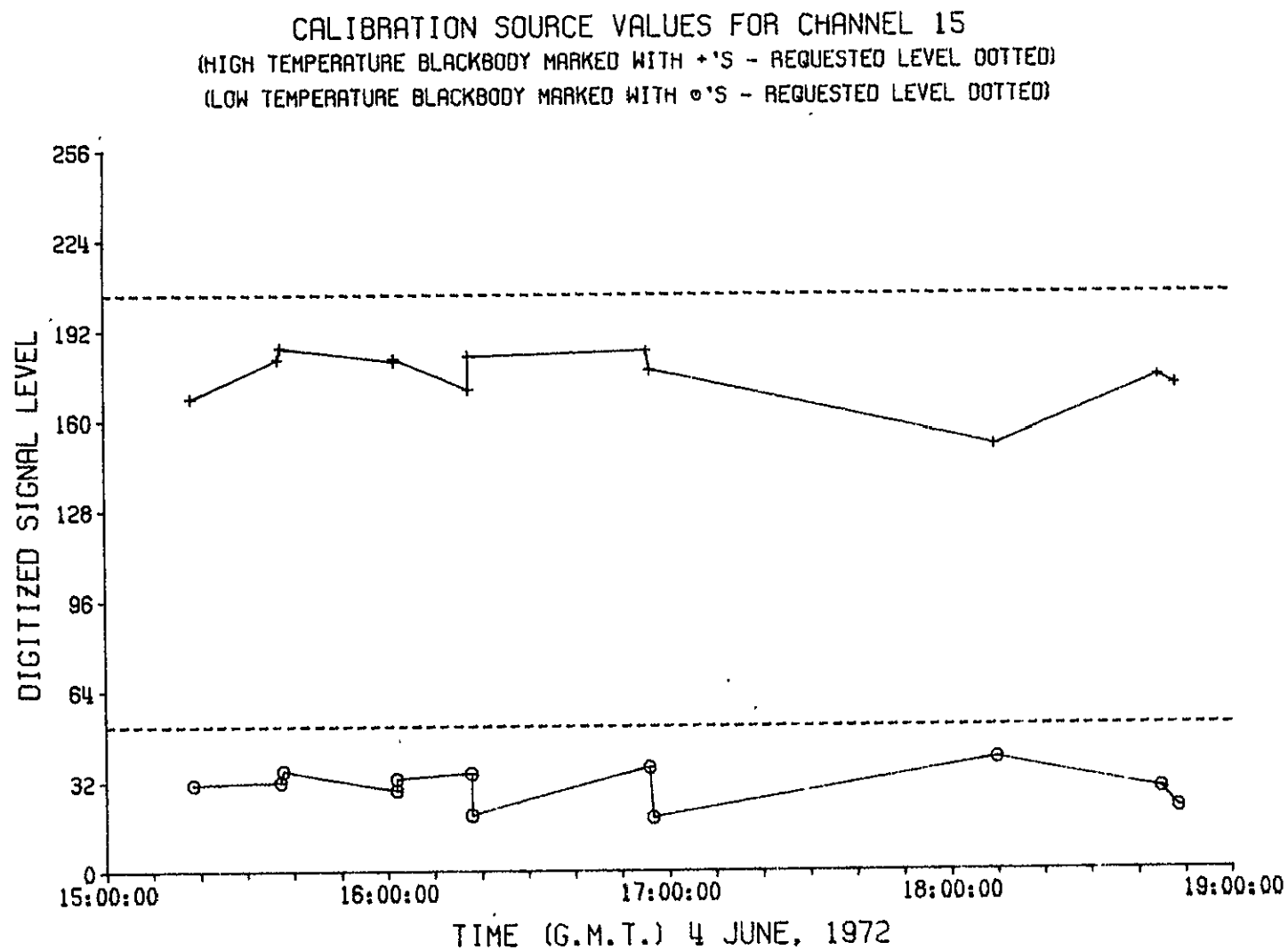


Figure 8.14

Figure 8.15



CALIBRATION SOURCE VALUES FOR CHANNEL 16
(HIGH TEMPERATURE BLACKBODY MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)

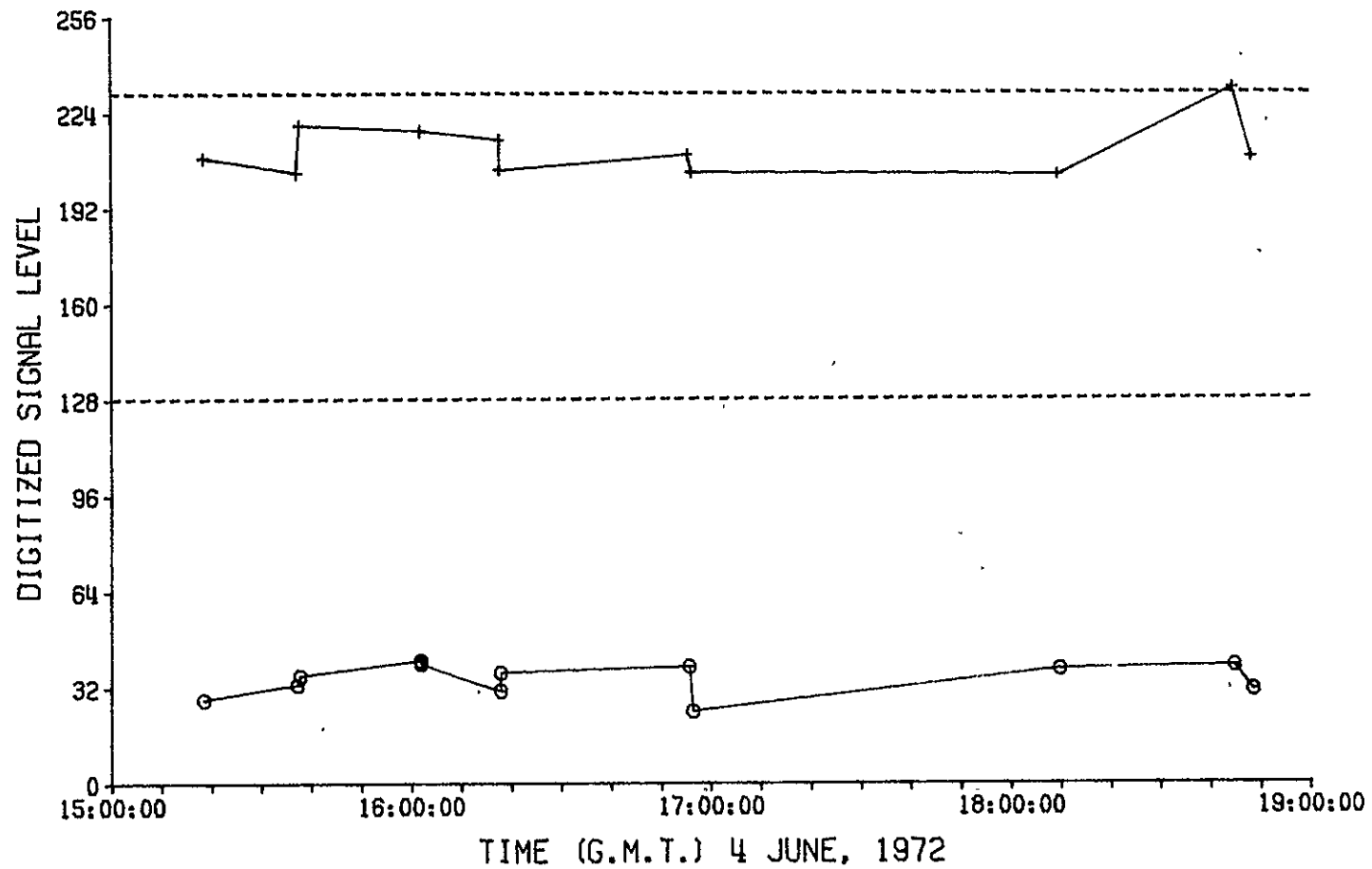
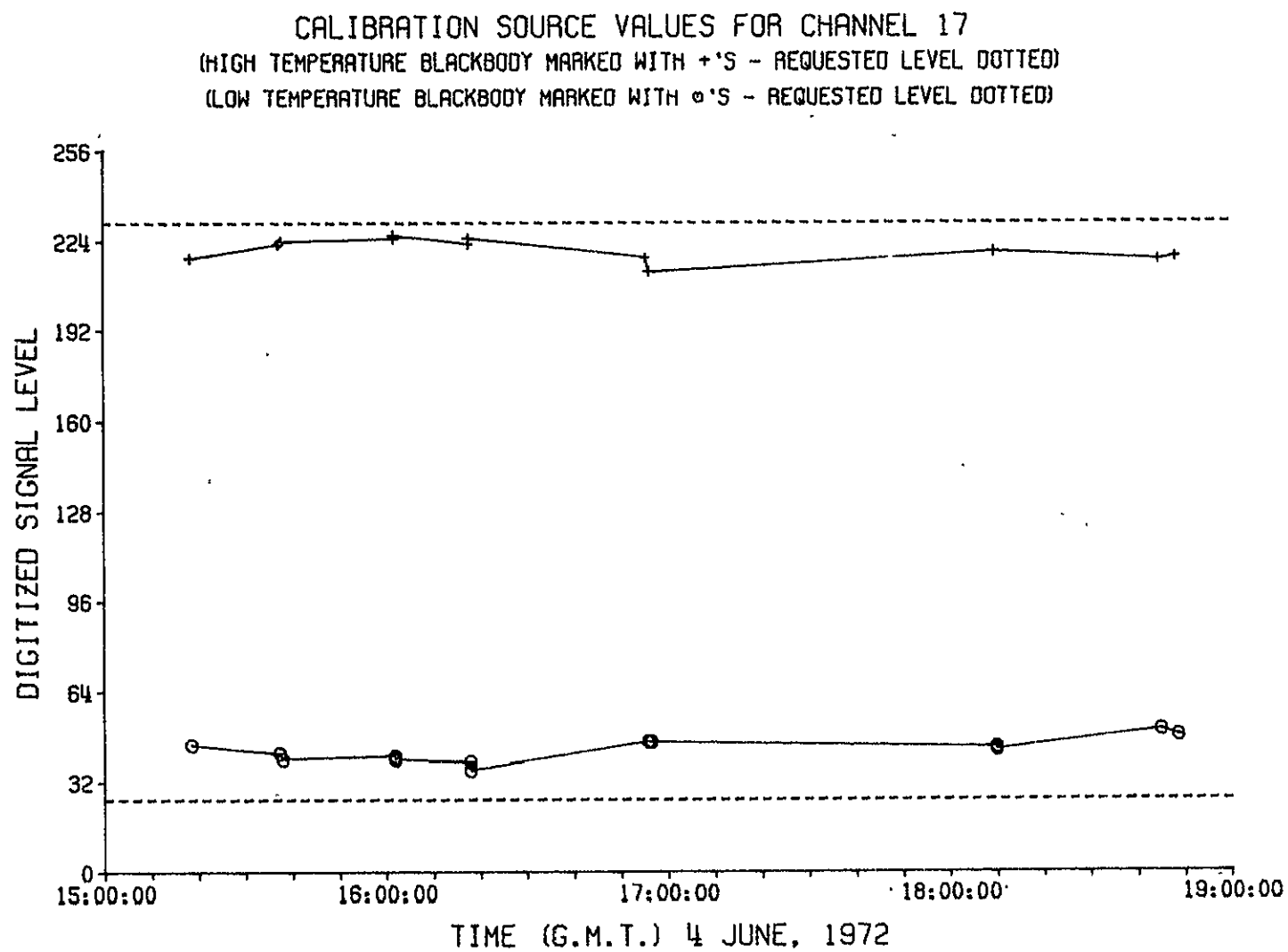


Figure 8.16

Figure 8.17



CALIBRATION SOURCE VALUES FOR CHANNEL 18
(HIGH TEMPERATURE BLACKBODY MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)

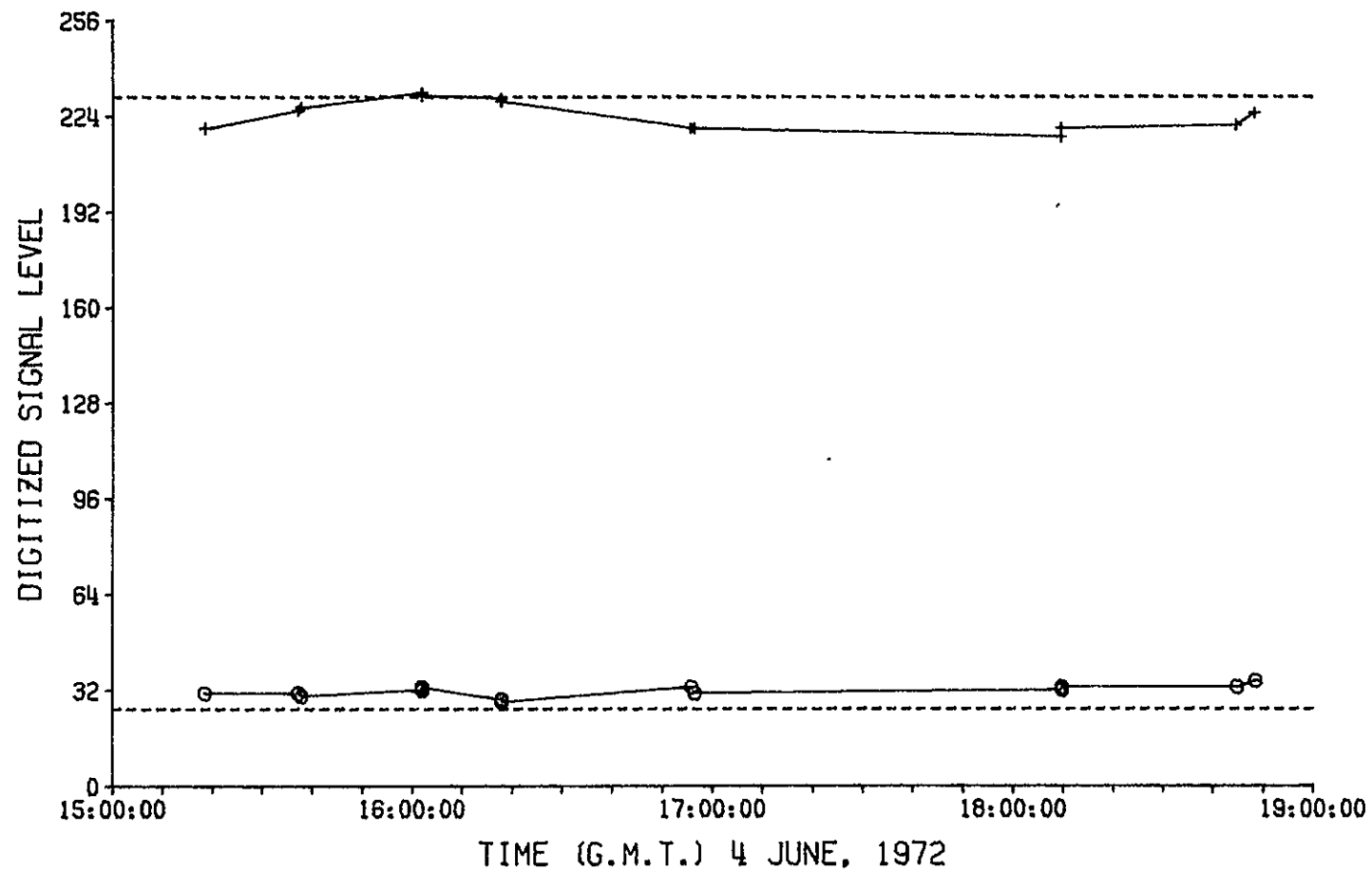
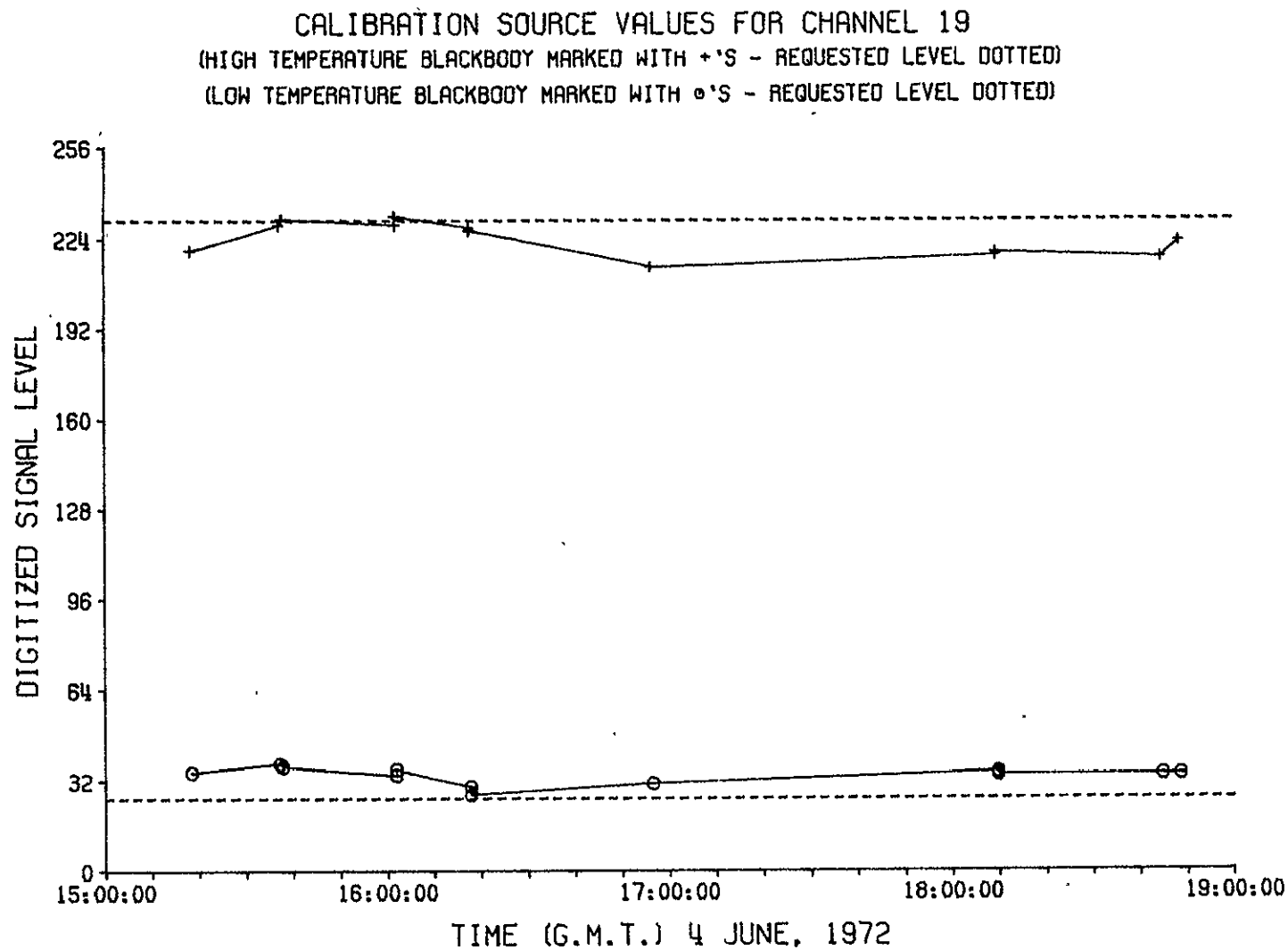


Figure 8.18

Figure 8.19

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:47:00 NOV 1, 1972 *
CONAMLOT, VERSION 1.0, P.F. LANBECK



CALIBRATION SOURCE VALUES FOR CHANNEL 20
(HIGH TEMPERATURE BLACKBODY MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH o 'S - REQUESTED LEVEL DOTTED)

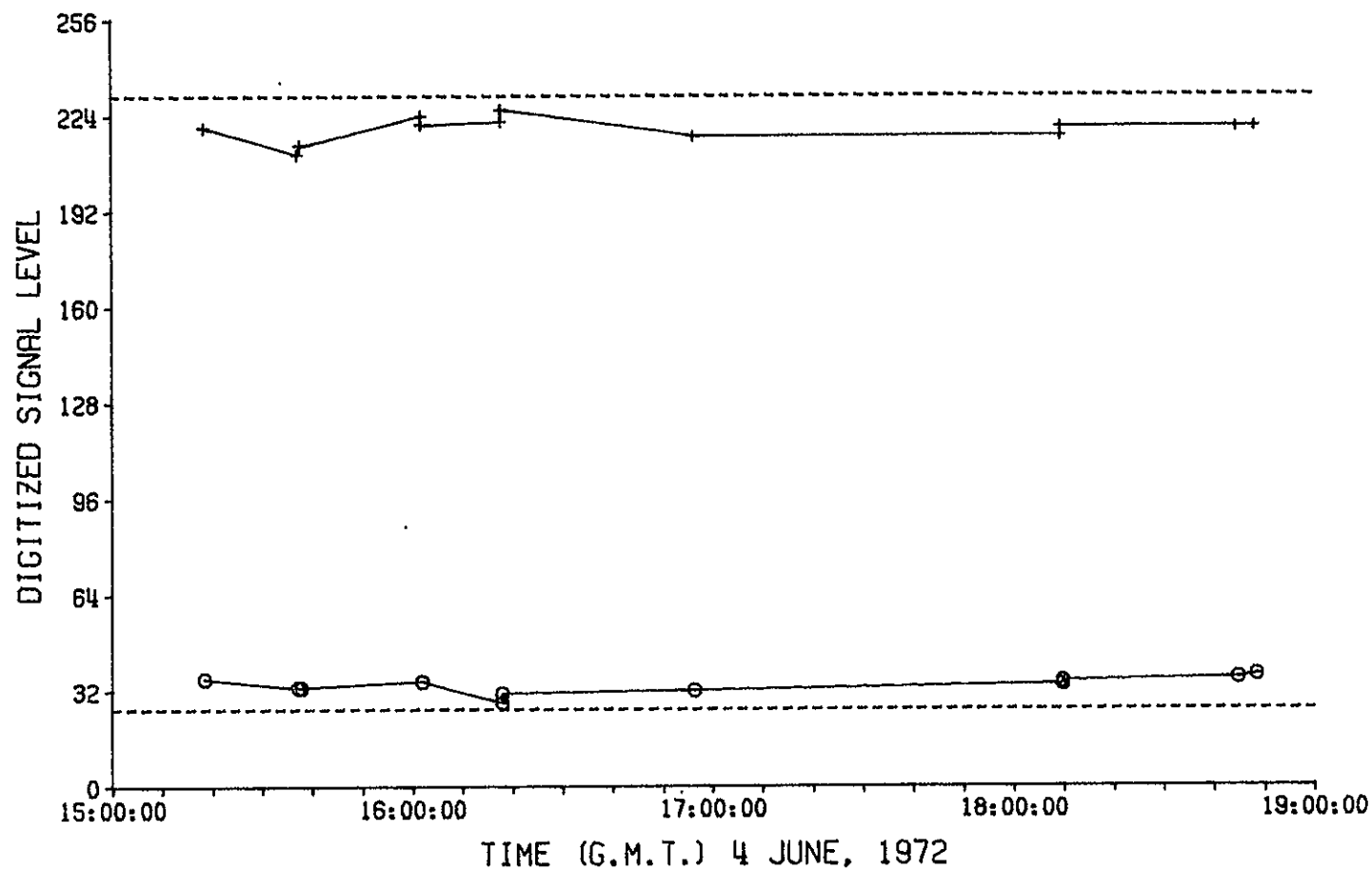
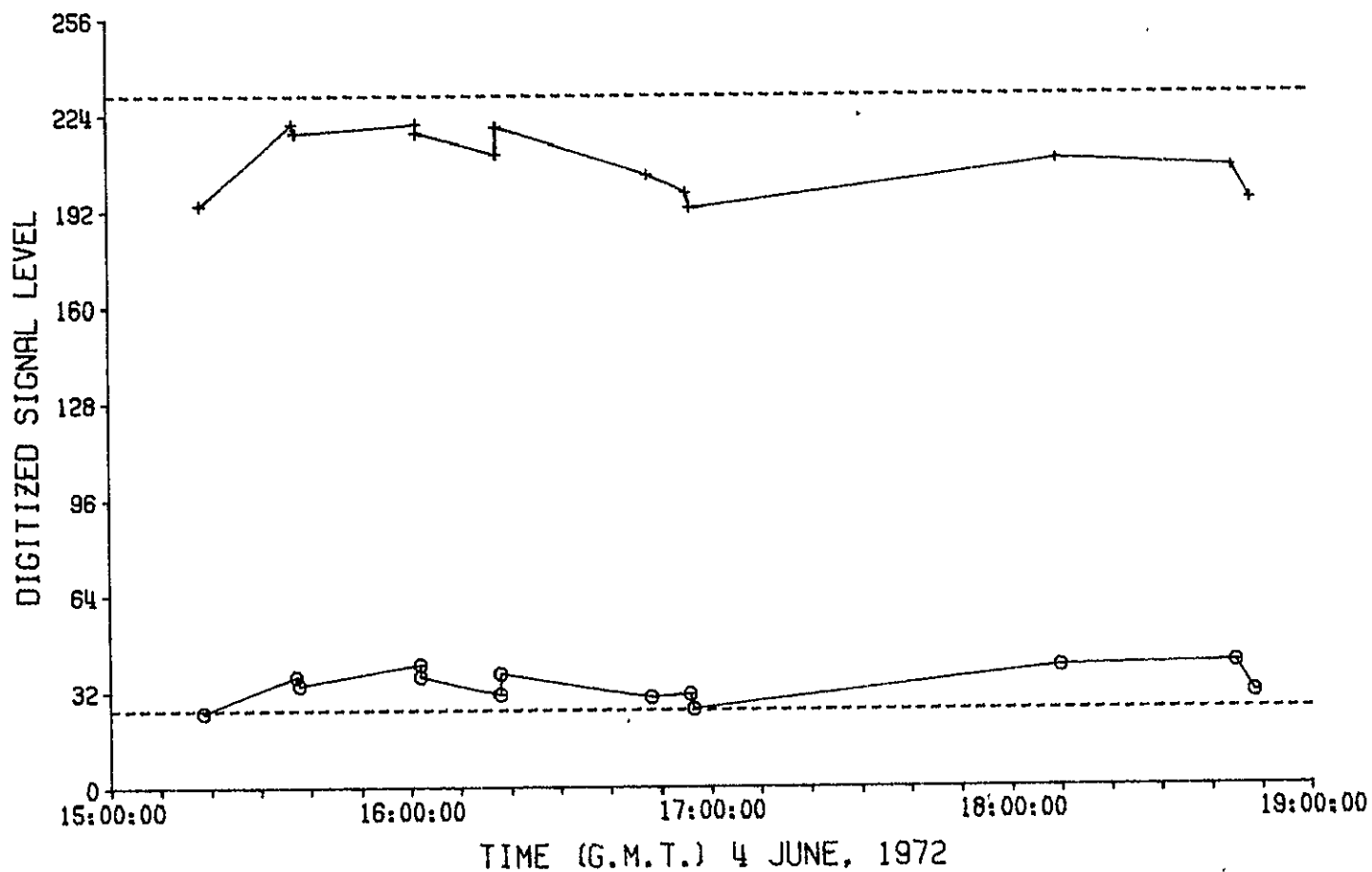


Figure 8.20

Figure 8.21

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:47:31 NOV 1, 1972 "
GRAPHLOT, VERSION 1.0, P.F. LAMBECKO

CALIBRATION SOURCE VALUES FOR CHANNEL 21
(HIGH TEMPERATURE BLACKBODY MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)



CALIBRATION SOURCE VALUES FOR CHANNEL 22
(HIGH TEMPERATURE BLACKBODY MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)

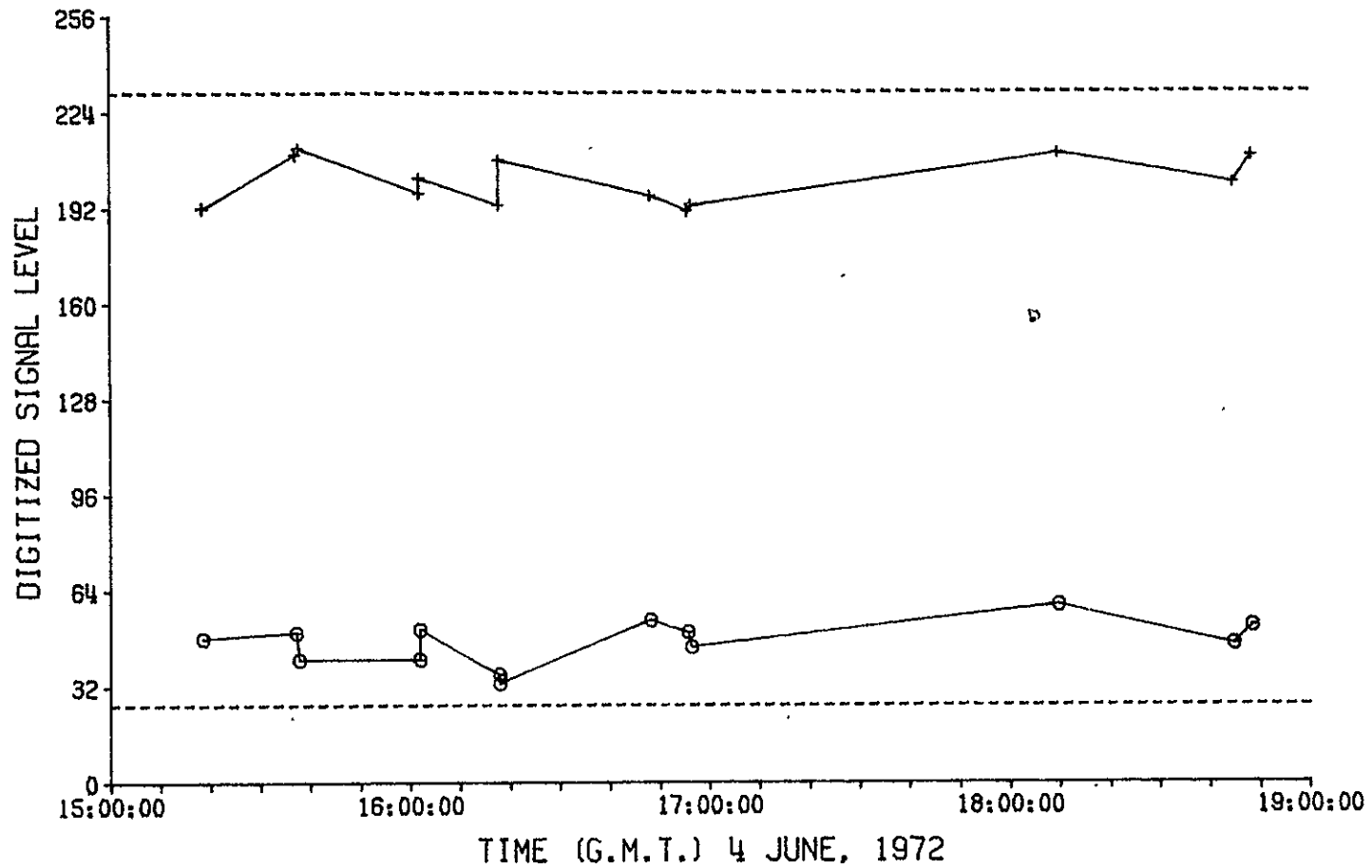
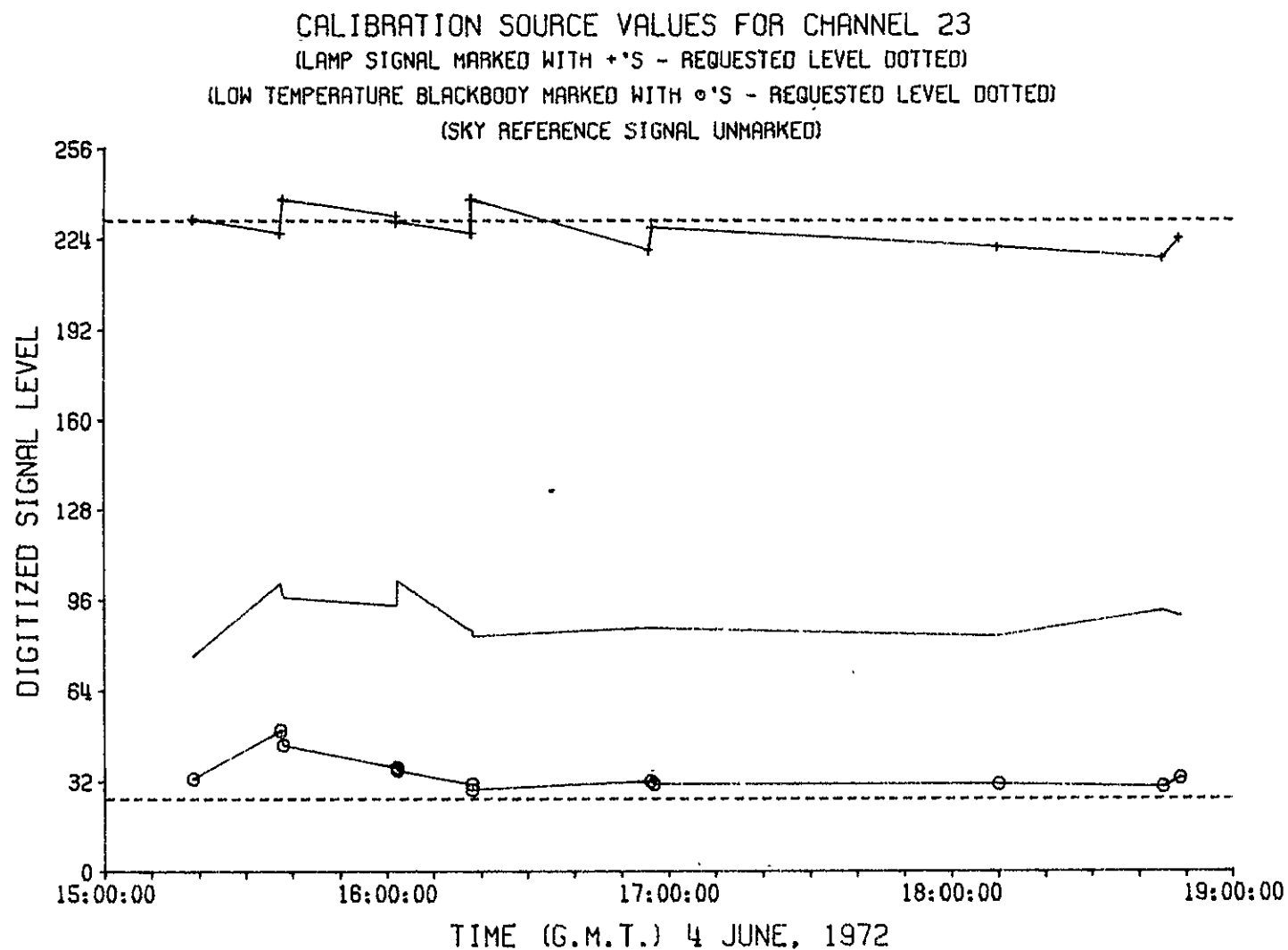


Figure 8.22

Figure 8.23

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:40:21 NOV 1, 1972 *
 (GRAMPLOT, VERSION 1.0, P.F. LAMBECK)



CALIBRATION SOURCE VALUES FOR CHANNEL 24
(LAMP SIGNAL MARKED WITH + 'S - REQUESTED LEVEL DOTTED)
(LOW TEMPERATURE BLACKBODY MARKED WITH O 'S - REQUESTED LEVEL DOTTED)
(SKY REFERENCE SIGNAL UNMARKED)

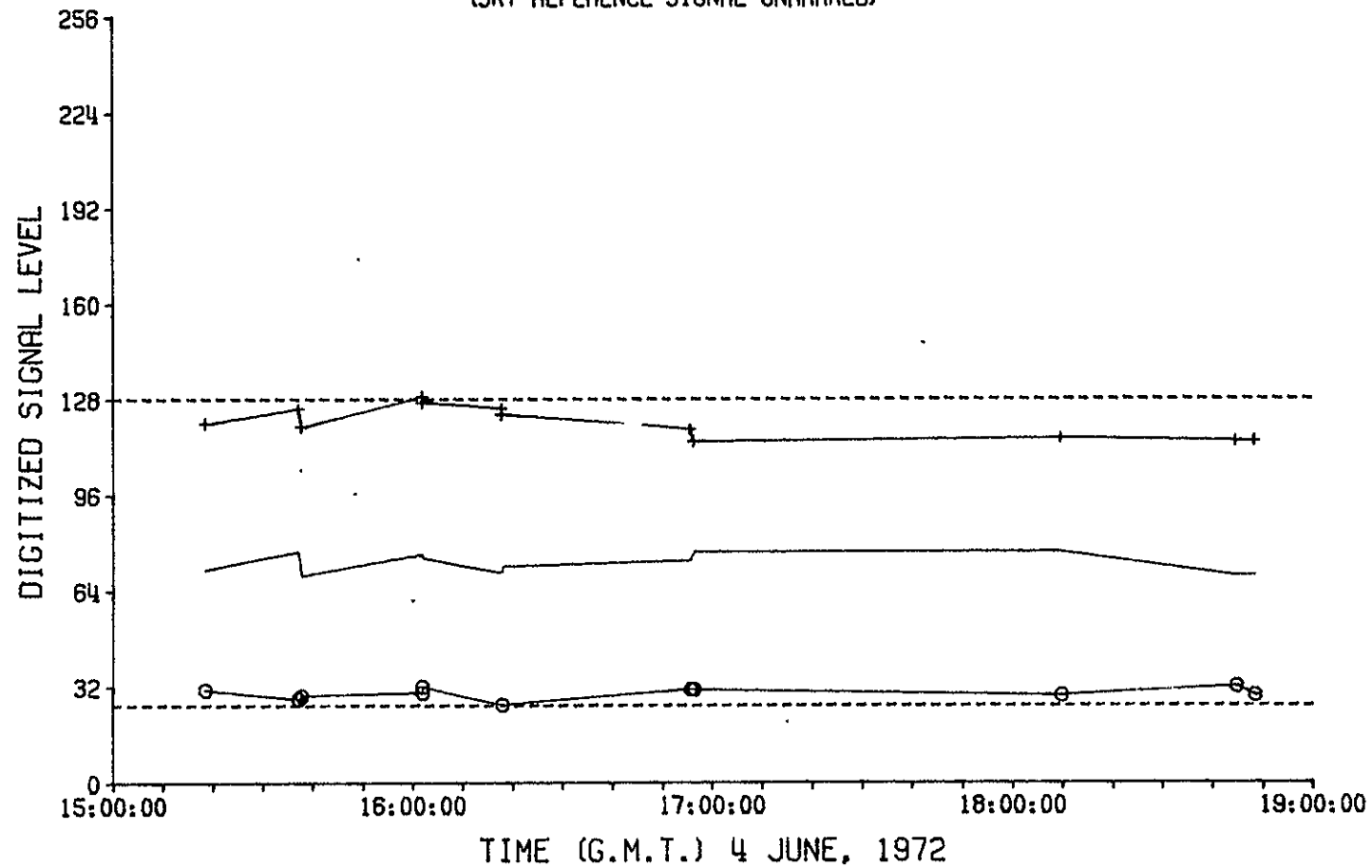


Figure 8.24

PRT-5 Performance

Figures 9.2 and 9.3 compare a portion of the PRT-5 data from run 2 (2 June, 14.7 thousand feet) to data from three thermal channels which cover portions of the spectrum sampled by the PRT-5. The data for these thermal channels is taken from the tape edit contoured in Figure 9.1, showing an outline of the shoreline of Belleville Lake (see also Figure 1.3). To correspond somewhat with the 2° field of view of the PRT-5, an average of 17 adjacent elements in each channel (representing 1.95° , but only one dimension of the PRT-5 field of view) is traced along a path running from land to water through the semicircular bay visible in Figure 9.1 near element 350. In Figure 9.2 these 17 elements center about element 350 (nadir) while in Figure 9.3 they follow a path 8 resolution elements ($.92^\circ$) to the right of nadir (centered on resolution element 358). Note that the PRT-5 data correlates best with the data plotted in Figure 9.3, indicating that the PRT-5 may be angled approximately 1° to the right of nadir. In Figures 9.2 and 9.3 the symbols correspond to every 4th data point plotted (every $.458^\circ$) for each thermal channel. Four of these symbol increments plus one additional data point (i.e., 17 data points or scan lines) is approximately equal to the field of view of the PRT-5 along the flight direction (1.95° vs. 2° for the PRT-5).

Figures 9.4 and 9.5 compare a portion of the PRT-5 data from run 12 (4 June, 1.7 thousand feet) to a 17 element average of data from three thermal channels which again cover portions of the PRT-5 sensitivity spectrum. The data from these thermal channels is taken from the tape edit contoured in Figure 10.2. Again the data corresponding to points centered approximately 1° to the right of nadir (Figure 9.5) shows the closest correlation with the PRT-5. Note the square "pulse" so prominent in the data from the thermal channels, corresponding to the tar paper strips on the ramp which were warmed by the sun, which is somewhat less prominent in the PRT-5 data due to its 2° field of view along the flight direction. (The 17 element averaging of the thermal channel data takes no account of this dimension in the PRT-5 field of view). The time discrepancy between the appearance of this "pulse" in the thermal channels and its appearance in the PRT-5 data indicates that the PRT-5 is probably not only looking 1° to the right of nadir, but 2° behind the scanner as well. This supposition is not contradicted by the data in Figures 9.2 and 9.3. Note that in Figures 9.4 and 9.5 every 8th data point plotted in the thermal channels (every $.916^\circ$) is marked, thus 2 symbol increments plus one data point (17 data points or scan lines again) approximately corresponds to the field of view of the PRT-5 along the flight direction (1.95° vs. 2° for the PRT-5).

One might expect a generally lower apparent temperature to be indicated for the PRT-5 at the higher altitude (Figures 9.2 and 9.3, 14.7 thousand feet) due to the cooler atmosphere absorbing and emitting more, proportionally, toward the ends of the 8 to 14 micron sensitivity band of the PRT-5 than in the scanner channels chosen for the plots; however, a similar discrepancy in indicated temperatures occurs for the low altitude

as well (Figures 9.4 and 9.5, 1.7 thousand feet). The low temperature and ΔT values used to calculate the indicated temperatures for the thermal channels in these plots were taken from the start ID housekeeping data for these edits (see documentation on plots). If these calibration parameters had been taken from the flight log (see Section 7 and Figure 7.3), the calculated temperatures for these thermal channels might have been approximately 1 degree lower, still leaving a discrepancy on the order of 1 or 2 degrees; hence it appears that there may be a calibration discrepancy between the scanner thermal references and the PRT-5.

MSS158-72-B, F3 L2 R2 (CLEAR) 14.7K. BELLEVILLE LAKE (06/15/72)
 06/04/72 15:37:41.4, RADAR ALT 14500 FT, TRUE HEADING 188.4°, DRIFT -08.0°
 V/H=0.0287 LOW TEMP=+10.8°C ΔT=36.2°C FILTER SELECT=1 27.678mSEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 0: CAL 2, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 02:05:22 AUG 22, 1972 *
 (CONTOUR, VERSION 2.0, P.F. LAMBECK)
 CONTOUR AT LEVEL S2 - 1 LINE X 1 ELEMENT AVERAGING
 PLOT ALL LINES, ALL ELEMENTS

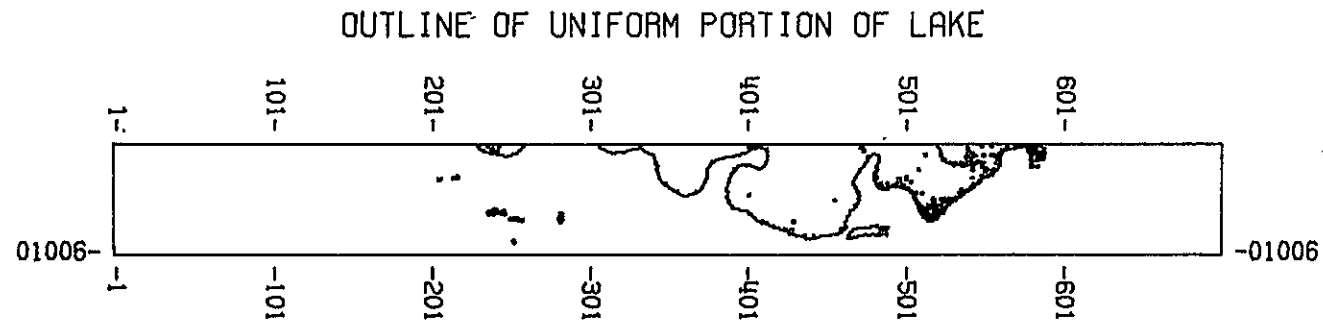


Figure 9.1

MS9158-72-B, F3 L2 R2 (CLEAR) 14.7K, BELLEVILLE LAKE 08/15/72
 08/04/72 15:37:41.4, RADAR ALT 14500 FT, TRUE HEADING 188.4°, DRIFT -08.0°
 V/H=0.0282 LOW TEMP=-10.8°C $\Delta T=38.2^\circ\text{C}$ FILTER SELECT=1 27.6794SEC/ELEMENT
 SEGMENT 0 OF 1
 CHANNEL 17: CAL 1, SCALE=1X, OFFSET=1 CHANNEL 19: CAL 1, SCALE=1X, OFFSET=1 CHANNEL 22: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 14:14:05 SEP 26, 1972 *
 WARMPL07, VERSION 1.0, P.F. LANBECK
 AVERAGE ELEMENTS 342-358, ALL LINES

PRT-5 DATA (2° FIELD OF VIEW) COMPARED WITH
 AVERAGE OF 17 ADJACENT ELEMENTS CENTERED AT NADIR
 AND TRACED ACROSS SCAN LINES FOR CHANNELS 17 (o), 19 (+), AND 22 (x)

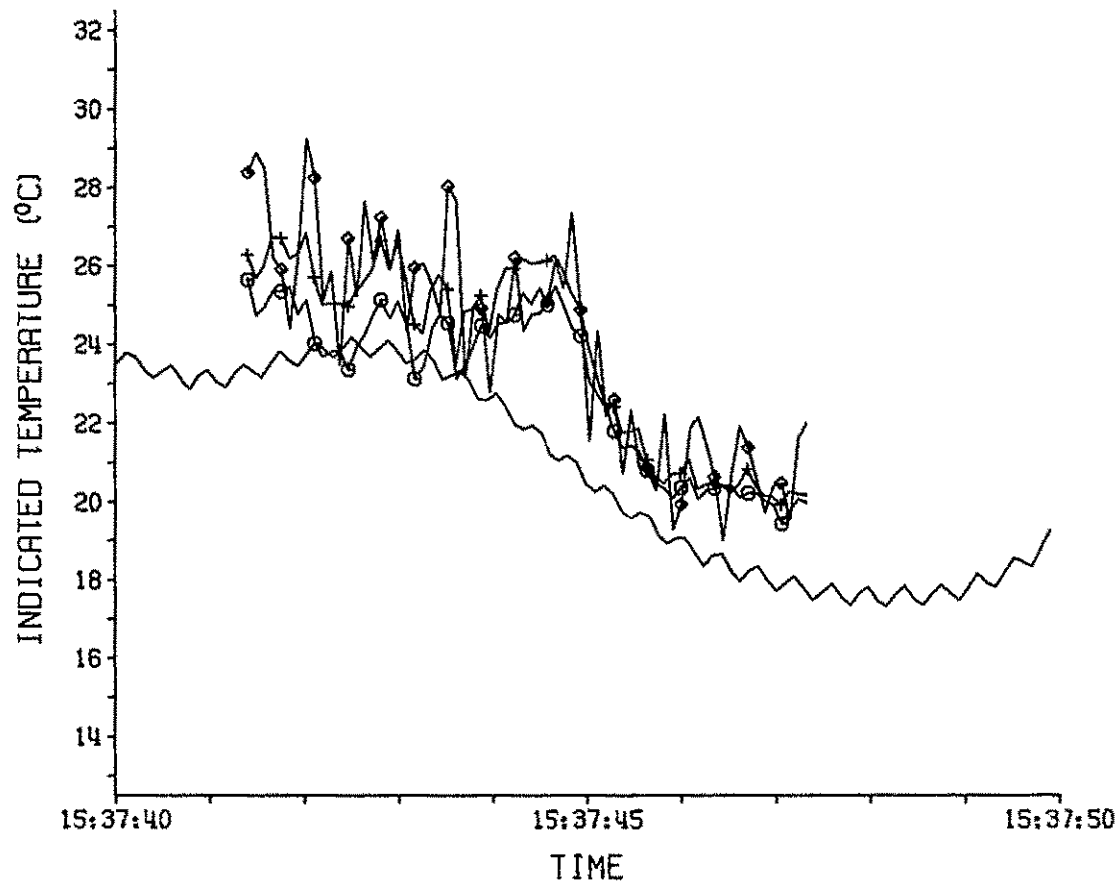


Figure 9.2

MSS158-72-8, F3 L2 R2 (CLEAR) 14.7K, BELLEVILLE LAKE (08/15/72)
08/04/72 15:37:41.4, RADAR ALT 14500 FT, TRUE HEADING 188.4°, DRIFT -08.0°
V/H=0.0287 LOW TEMP=-10.8°C $\Delta T=38.2^\circ\text{C}$ FILTER SELECT=1 27.679 $\mu\text{SEC/ELEMENT}$
SEGMENT 0 OF 1
CHANNEL 17: CAL 1, SCALE=1X, OFFSET=1 CHANNEL 19: CAL 1, SCALE=1X, OFFSET=1 CHANNEL 22: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 14:15:50 SEP 28, 1972 *
DRAWPLOT, VERSION 1.0, P.F. LAMBECKO
AVERAGE ELEMENTS 350-368, ALL LINES

PRT-5 DATA (2° FIELD OF VIEW) COMPARED WITH
AVERAGE OF 17 ADJACENT ELEMENTS CENTERED 1° TO RIGHT OF NADIR
AND TRACED ACROSS SCAN LINES FOR CHANNELS 17 (o), 19 (+), AND 22 (x)

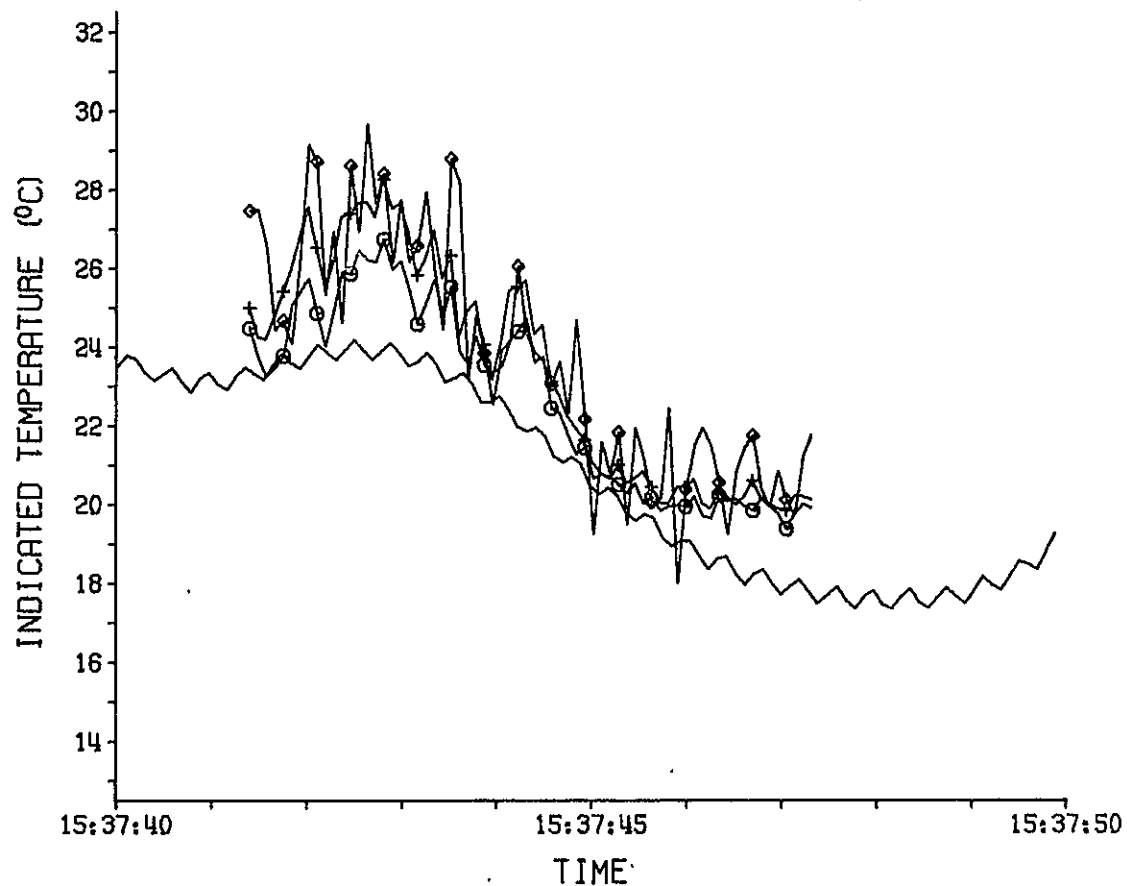


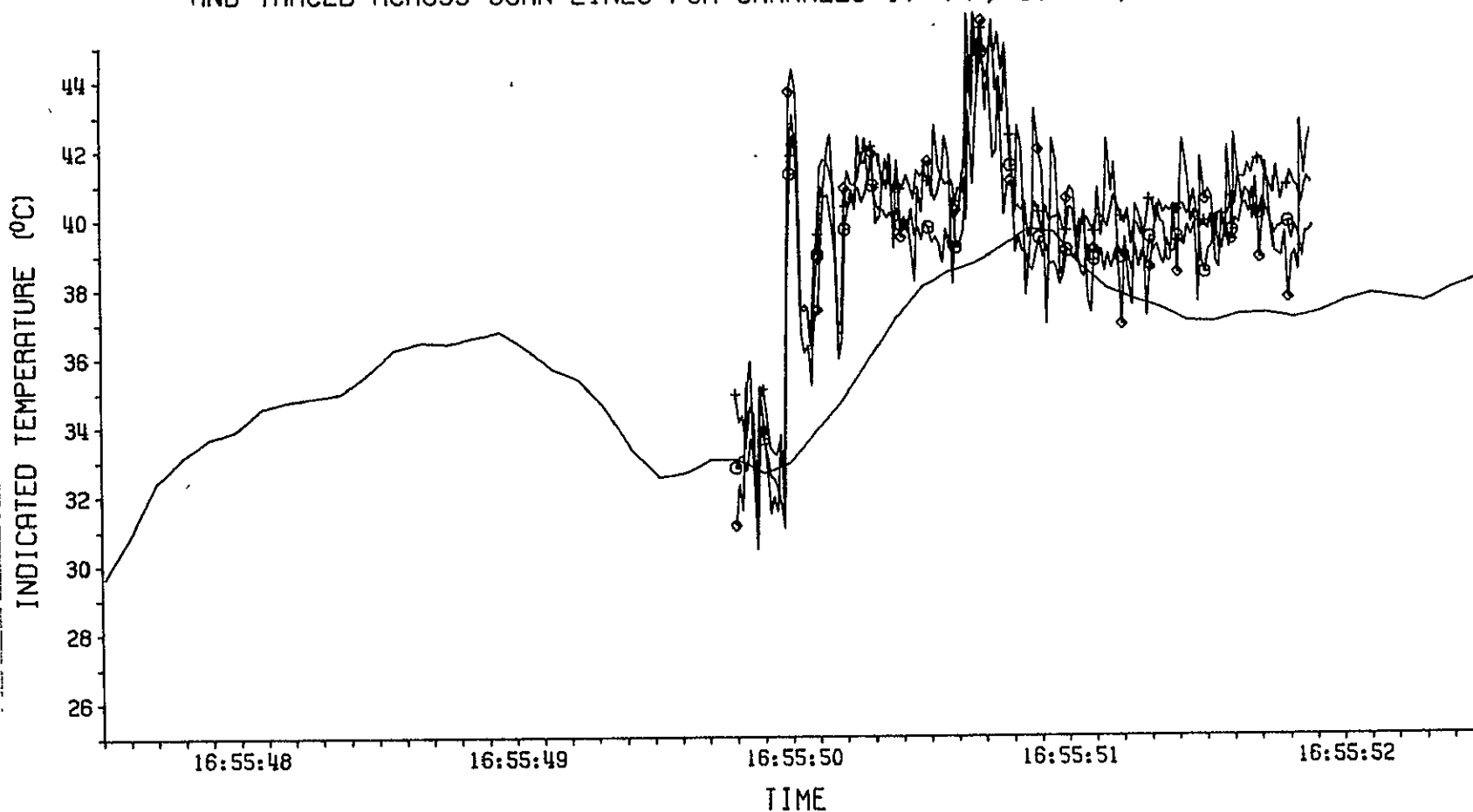
Figure 9.3

MSS156-72-0, F3 L2 912 (CLEAR) 1.7K, PANELS, ETC. ON RAMP (06/15/72)
 06/04/72 16:55:48.8, RADAR ALT 01590 FT, TRUE HEADING 173.5°, DRAFT +03.6°
 V/M=0.1607 LON TEMP=+11.2°C $\Delta T=36.7^\circ\text{C}$ FILTER SELECT=1 3.878 $\mu\text{SEC/ELEMENT}$
 SEGMENT 0 OF 1
 CHANNEL 17: CAL 1, SCALE= 1X, OFFSET=1 CHANNEL 18: CAL 1, SCALE= 1X, OFFSET=1 CHANNEL 22: CAL 1, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 16:38:35 OCT 2, 1972 *
 (GRAMPLOT, VERSION 1.0, P.F. LAMBECK)
 AVERAGE ELEMENTS 342-350, ALL LINES

Figure 9.4

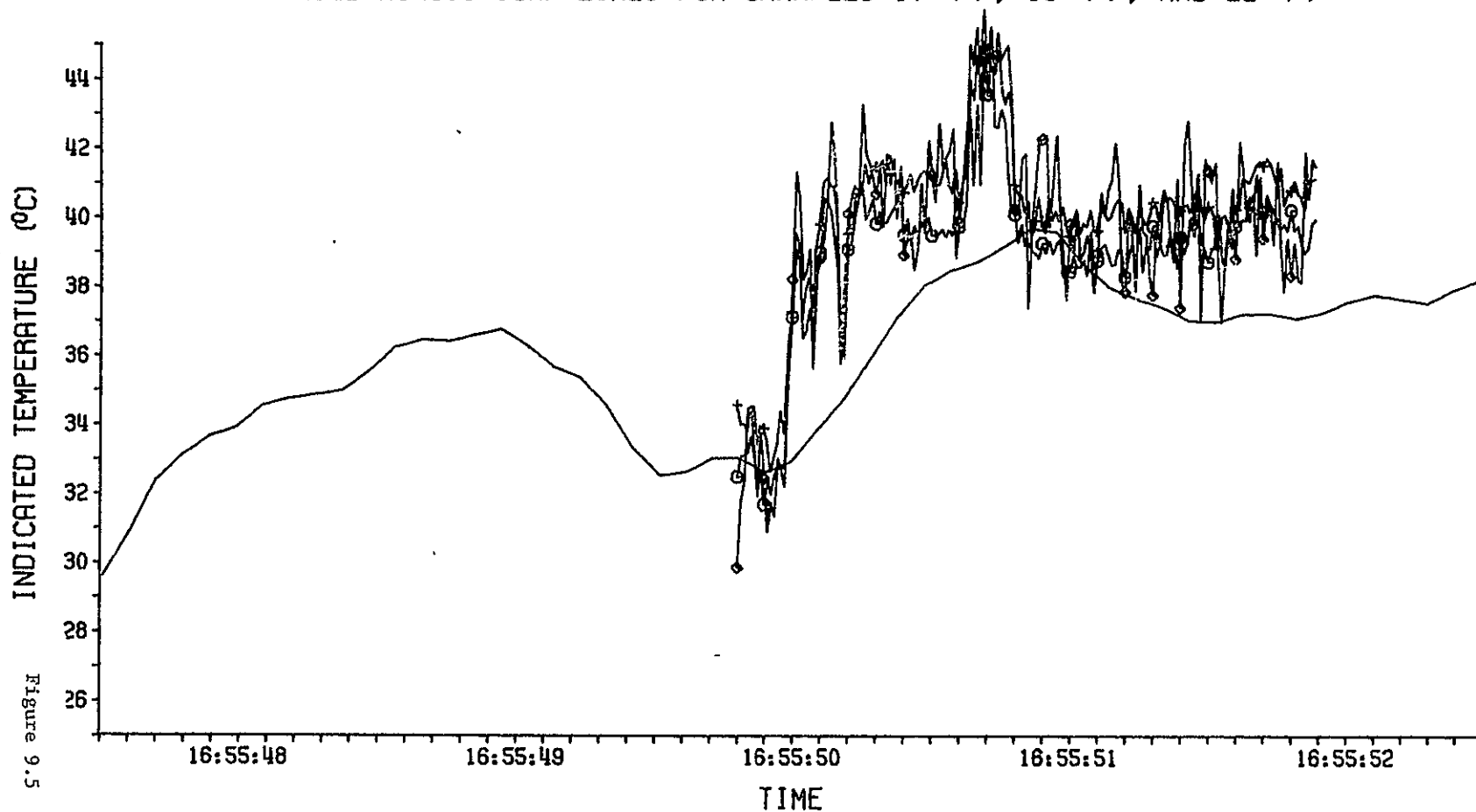
PRT-5 DATA (2° FIELD OF VIEW) COMPARED WITH
 AVERAGE OF 17 ADJACENT ELEMENTS CENTERED AT NADIR
 AND TRACED ACROSS SCAN LINES FOR CHANNELS 17 (o), 18 (+), AND 22 (◊)



MS156-72-0, F3 L2 R12 (CLEAR) 1.7K, PANELS, ETC, ON RAMP (08/15/72)
 08/04/72 16:55:49.8, NAORA ALT 01580 FT, TRUE HEADING 173.5°, DRIFT +03.8°
 V/H-0.1607 LOW TEMP=-11.2°C $\Delta T=36.7^\circ\text{C}$ FILTER SELECT=1 3.878 $\mu\text{SEC/ELEMENT}$
 SEGMENT 0 OF 1
 CHANNEL 17: CAL 1, SCALE=1X, OFFSET=1 CHANNEL 18: CAL 1, SCALE=1X, OFFSET=1 CHANNEL 22: CAL 1, SCALE=1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 10:41:17 OCT 2, 1972 *
 (DRAWPL07, VERSION 1.0, P.F. LANDECKO)
 AVERAGE ELEMENTS 360-366, ALL LINES

PRT-5 DATA (2° FIELD OF VIEW) COMPARED WITH
 AVERAGE OF 17 ADJACENT ELEMENTS CENTERED 1° TO RIGHT OF NADIR
 AND TRACED ACROSS SCAN LINES FOR CHANNELS 17 (o), 18 (+), AND 22 (x)



10. Moiré Patterns

Moiré patterns are often observed on television newscasts when the news commentator wears a suit or tie which has a pattern made up of contrasting elements similar in dimensions to the width of one scan line. Similar patterns arise from time to time in multispectral scanner data, particularly in data representing a contrasty row crop viewed from above. The moiré pattern consists of the loci of areas in the data where sampling is out of phase rather than in phase with the two contrasting elements of the true pattern which is being viewed. These loci usually appear as gray bands with a level of grayness midway between the levels corresponding to the separate elements of the original true pattern. Obviously the signals corresponding to the gray bands of the moiré pattern do not accurately correspond to the signal level of either component of the original true pattern, hence these bands represent areas where a potentially useful signal has been obscured due to the resolution limitations of the scanner. While the loss of a few resolution elements of data corresponding to a few individual corn plants might be tolerated, the loss of data due to sampling out of phase with an entire cornfield can be substantial. To this extent moiré patterns are a matter of some concern in multispectral scanning.

Figure 10.1 is a digital graymap of data from run 12 (4 June) for channel 2. In this plot the signal level from each resolution element in channel 2 is translated into a scribble which fills all, part, or none of a resolution cell defined to be .04 inches square. The more scribbling, the darker the resolution cell appears from a distance. In this plot 16 separate scribbles have been defined, corresponding to 16 distinct shades of gray, ranging from black (a filled resolution cell) to a single dot .02 inches in diameter. A blank cell constitutes a 17th gray level. The differences between consecutive levels of gray are in general just barely perceptible to the eye, with the exception of three levels near the center of the range of the grayscale which are slightly more abrupt in contrast. The overall result of the plot (when viewed from a great distance) is an approximate qualitative equivalent of a black and white film print of data from the chosen channel with enhanced contrast near the middle of the dynamic range of the film. Figure 10.1 may be compared with Figures 1.2 and 1.6. Note the appearance of the tar paper strips in this graymap; in particular note the separated areas over which the seven tar paper strips can be seen individually. The diagonal boundaries separating these areas constitute the bars of a moiré pattern. In Figure 10.2, a contour plot of the tape edit from which Figure 10.1 was taken, these bars of the moiré pattern can be seen as white patches where definition of the tar paper strips has been lost, since the contouring is done for one signal level just below that corresponding to the bars of the moiré pattern and at a second level completely above any signal occurring in the tar paper strip area. (These signal levels - 112 and 170 - can be observed relative to one scan line segment from this edit for channel 2 in Figure 6.20. This scan line crosses the tar paper strips between elements 335 and 367.) Figure 10.3 is a plot of a series of scan lines from the tape edit of Figures

10.1 and 10.2 (plotted with 100 resolution elements per inch). The wavy portion of the signals covering about .3 inches near the middle of most of the scan lines shows the effect of scanning in and out of phase with the tar paper strips which creates a moiré pattern.

Figure 10.4 is a digital graymap of data from run 12 (for channel 2) for the flight of 2 June. This figure may be compared with Figures 1.1 and 1.5. The most serious moiré patterns are generally caused by scanning nearly, but not quite, in line with the stripes of some other true pattern as in Figures 10.1 and 10.2. On 2 June the intent was to show that moiré patterns could also arise from digitizing data not quite in phase with the stripes of an existing pattern (a color television hexagonal matrix picture tube provides even more opportunities for moiré patterns). For this purpose the tar paper strips were lined up parallel to the flight line. Note once again that regions can be identified where the tar paper strips appear separated. Between these regions are bands of a moiré pattern representing areas where definition of the tar paper strips is lost. In Figure 10.5, a contour plot of the tape edit from which Figure 10.4 was taken, these bands can be identified as white patches running through the tar paper strip region. Figure 10.6 plots a series of resolution elements traced across scan lines through this edit (100 scan lines per inch). Note the low frequency waves running through the portions of these traces representing response to the tar paper area (starting .4 inches from the left edge of each trace and ending .8 inches from the left edge) indicating the moiré effect. In non-digitized data this particular instance of the moiré pattern would not have occurred. Note in this case that although truly representative data for the tar paper strips (as well as separation from their surroundings) has been lost in the bars of the moiré pattern, from a standpoint of absolute reflectance calibration none of this particular data for these strips could be truly representative of their full signal level anyway due to the inherent response limitations of the scanner caused by the aperture size and the integrate and hold circuitry. For strips parallel to the flight line, fully representative data can only barely be obtained for strips which are 2 resolution elements wide and cannot be guaranteed unless these strips are at least 3 resolution elements wide (barring other response limitations). Strips 3 resolution elements wide would give rise to virtually no moiré effect regardless of their orientation. In the instance of Figures 10.1-10.3 for 4 June, fully representative data for the tar paper strips could be obtained between the bars of the moiré pattern in spite of the 1 resolution element width of these strips, since the integrate and hold circuitry primarily affects consecutive resolution elements within a scan line and has minimal effect between successive scan lines (the aperture affects both).

Note the effect of a "channel swap" between channels 1 and 2 which is visible in Figures 10.1 and 10.2 during scan line 3570. During the editing of data from the original flight tape onto the 9-track tape we obtained, a tape reading error (skipping over data from one resolution element in channel 2) caused data from channel 1 (which alternates with channel 2 on the flight tape) for the succeeding resolution element to be

read instead. Once this happened, the flight tape apparently continued to be read out of phase for the remainder of that scan line (in channels 1 and 2). Succeeding scan lines were transcribed properly (at least for channel 2).

MSS156-72-0, F3 L2 R12 (CLEAR) 1.7K, PANELS, ETC. ON RAMP (06/15/72)
 06/04/72 16:55:49.8, RADAR ALT 01590 FT, TRUE HEADING 173.5°, DRIFT +03.6°
 V/H=0.1687 LON TEMP=-11.2°C ΔT=36.7°C FILTER SELECT=1 3.979μSEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 13:56:52 SEP 28, 1972 "
 (GRAYPLOT, VERSION 1.0, P.F. LANBECK)
 SCALE LEVELS 56-184, PLOT LEVELS 0-200, 1 LINE X 1 ELEMENT AVERAGING
 PLOT LINES 3440-3580, ELEMENTS 280-480

PANELS, TAR PAPER STRIPS, AND RESOLUTION CHART ON RAMP

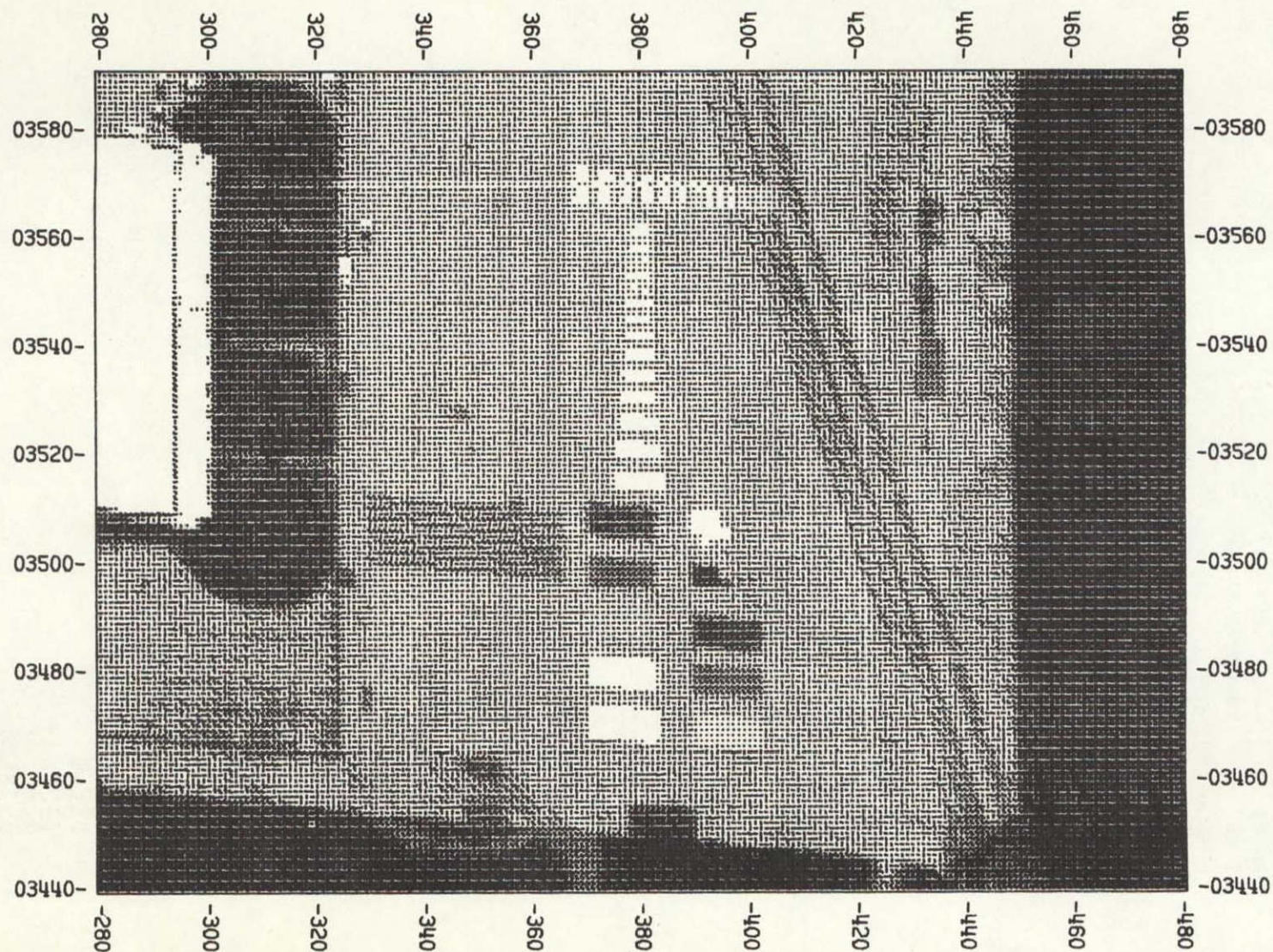


Figure 10.1

MSS156-72-0. F3 L2 R12 (CLEAR) 1.7K. PANELS, ETC. ON RAMP 086/15/72
 06/04/72 16:55:49.0. RADAR ALT 01590 FT, TRUE HEADING 173.5°, DRIFT +03.6°
 V/H=0.1687 LOW TEMP=-11.2°C ΔT=36.7°C FILTER SELECT=1 3.878μSEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 17:53:24 SEP 21, 1972 "
 (CONTOUR, VERSION 2.0, P.F. LAMBECK)
 CONTOUR AT LEVELS 112,170 - 1 LINE X 1 ELEMENT AVERAGING
 PLOT ALL LINES, ALL ELEMENTS

OUTLINES OF BUILDINGS, PANELS, ETC.

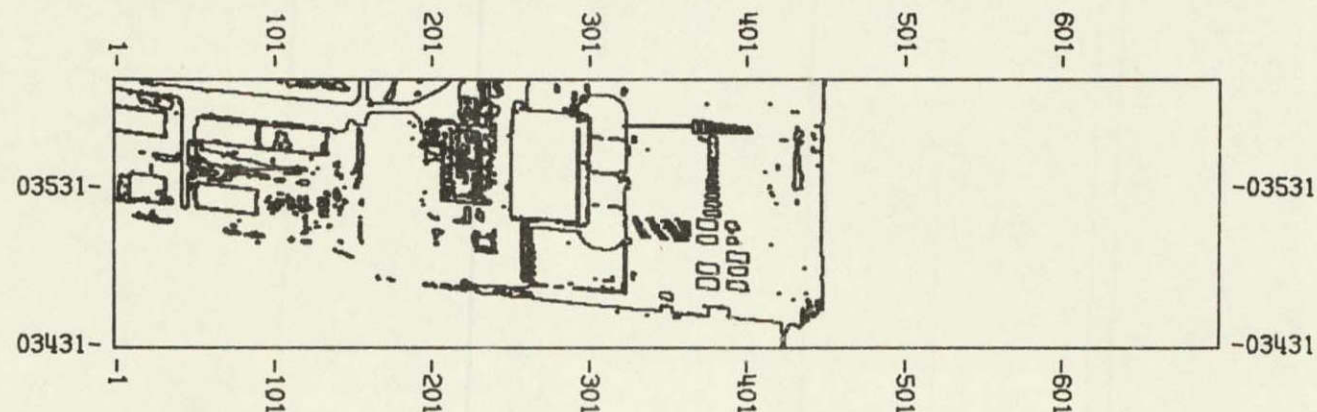


Figure 10.2

MS9158-72-0, F3 L2 R12 (CLEAR) 1.7K, PANELS, ETC. ON RAMP (08/15/72)
08/04/72 18:55:49.8, RADAR ALT 01590 FT, TRUE HEADING 173.5°, DRIFT +03.8°
V/H=0.1887 LOW TEMP=-11.2°C $\Delta T=38.7^{\circ}\text{C}$ FILTER SELECT=1 3.979 $\mu\text{SEC/ELEMENT}$
SEGMENT 1 OF 1
CHANNEL 2: CAL 2, SCALE=1X, OFFSET=1
SCAN LINES 03495-03515, RESOLUTION ELEMENTS 1-700

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 18:56:58 SEP 26, 1972 "
UTRACE, VERSION 2.0, P.F. LAMBECH
1/4 INCH SPACING, 1 INCH MAX AMPLITUDE, 1 LINE X 1 ELEMENT AVERAGING
PLOT LINES 03495-3515, ALL ELEMENTS, AND CAL SOURCES

CONSECUTIVE A-TRACES CROSSING TAR PAPER STRIPS, ETC.

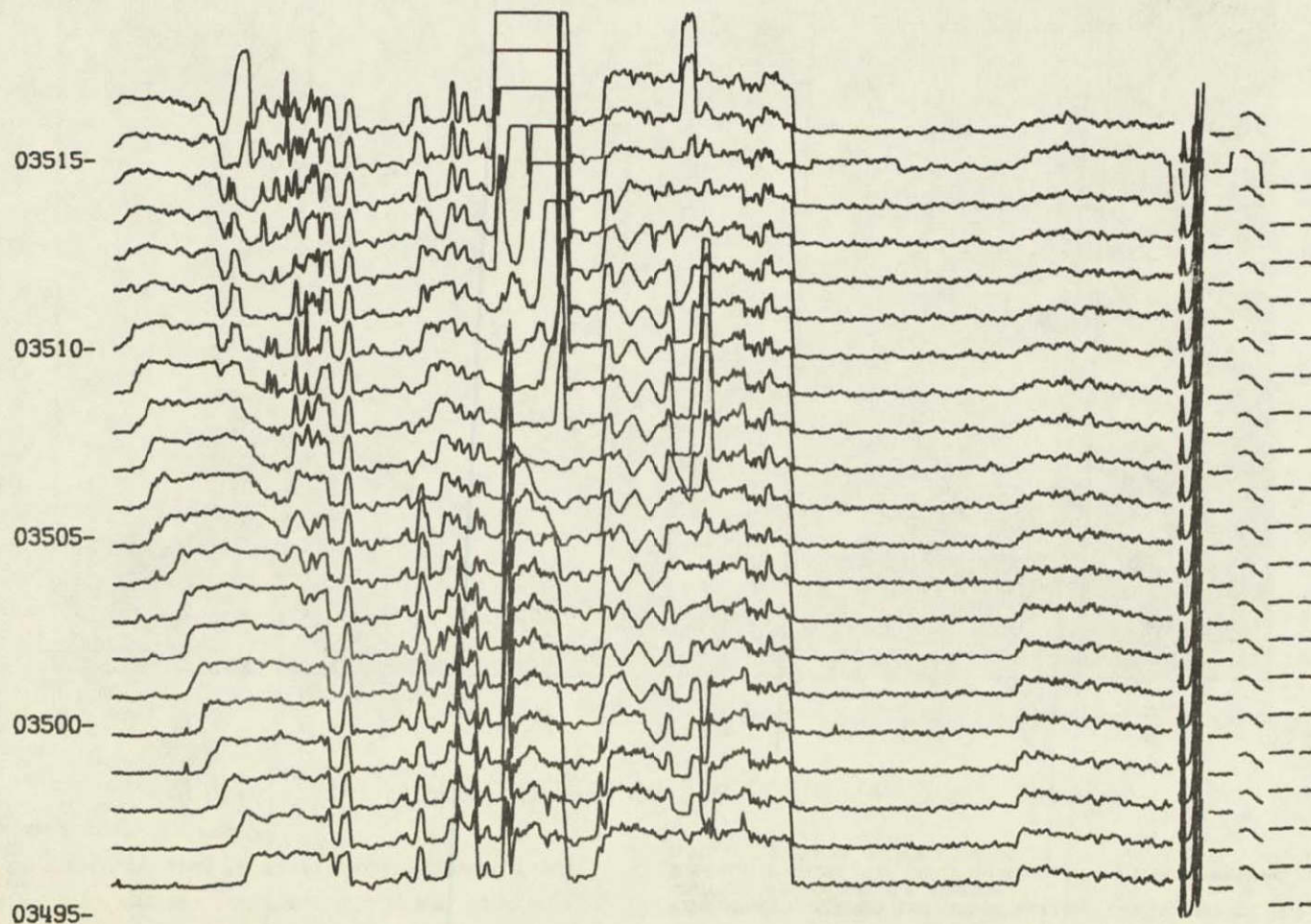


Figure 10.3

NSS154-72-8, F2 L2 R12 (OVERCAST) 1.7K, PANELS, ETC. ON RAMP (R6/15/72)

V/H=0.1687 LOW TEMP=+11.0°C $\Delta T=36.7^\circ\text{C}$ FILTER SELECT=1 3.95 μSEC /ELEMENT
SEGMENT 1 OF 1
CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 13:35:31 SEP 28, 1972 "
(GRAYPLOT, VERSION 1.0, P.F. LAMBECK)
SCALE LEVELS 42-106, PLOT LEVELS 0-114, 1 LINE X 1 ELEMENT AVERAGING
PLOT LINES 3550-3700, ELEMENTS 300-500

PANELS, TAR PAPER STRIPS, AND RESOLUTION CHART ON RAMP

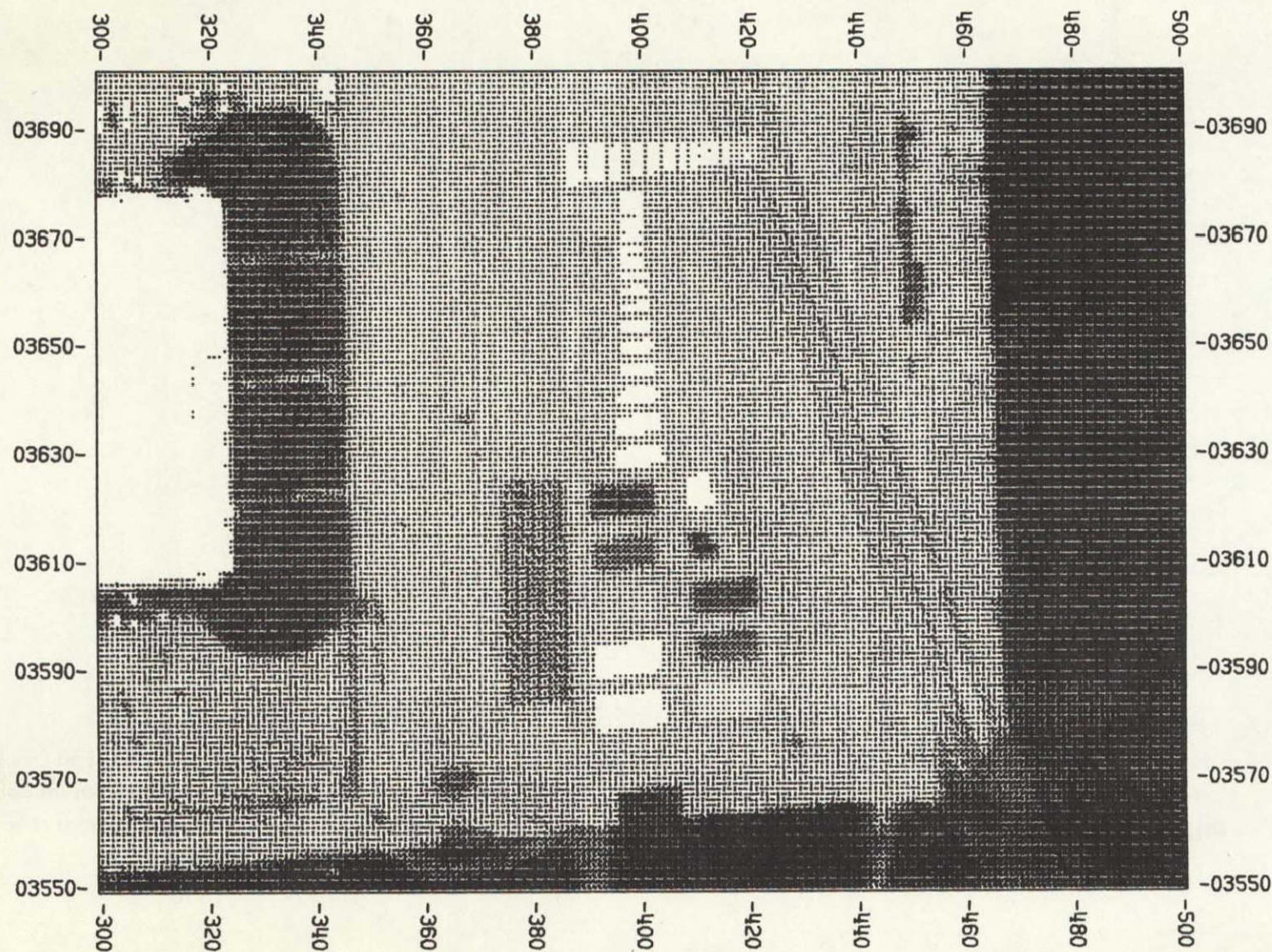


Figure 10.4

MS9154-72-8, F2 L2 R12 (OVERCAST) 1.7K, PANELS, ETC. ON RAMP (R6/15/72)

V/H=0.169? LOW TEMP=-11.0°C $\Delta T=36.7^{\circ}\text{C}$ FILTER SELECT=1 3.954 $\mu\text{SEC/ELEMENT}$
SEGMENT 1 OF 1
CHANNEL 2: CAL 2, SCALE= 1X , OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 13:58:35 SEP 27, 1972 *
(CONTOUR, VERSION 2.0, P.F. LAHBECK)
CONTOUR AT LEVELS 70.112 - 1 LINE X 1 ELEMENT AVERAGING
PLOT ALL LINES, ALL ELEMENTS

OUTLINES OF BUILDINGS, PANELS, ETC.

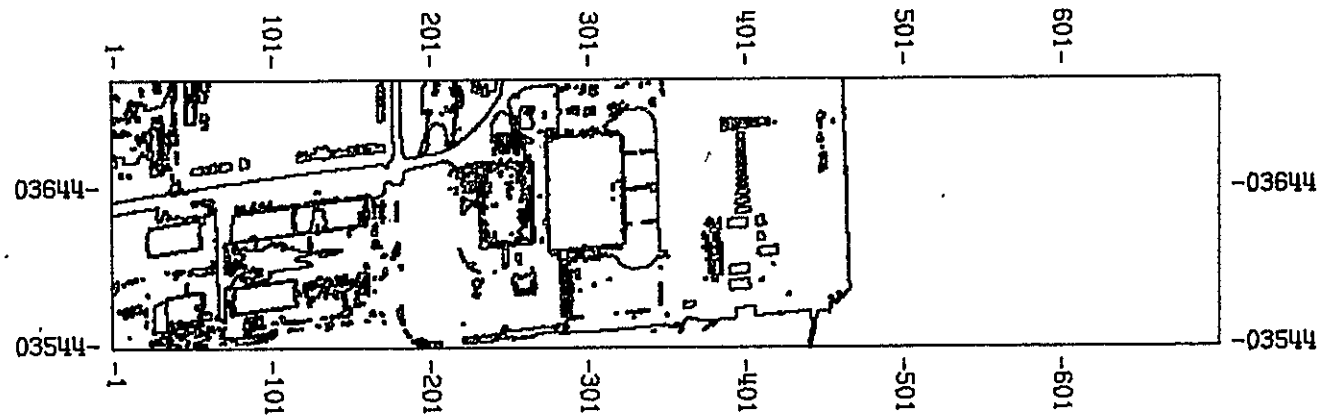


Figure 10.5

MSS154-72-B, F2 L2 R12 (OVERCAST) 1.7K, PANELS, ETC. ON RAMP (R6/15/72)

V/H=0.1697 LOW TEMP=+11.0°C $\Delta T=36.7^{\circ}\text{C}$ FILTER SELECT=1 3.954 $\mu\text{SEC/ELEMENT}$

SEGMENT 1 OF 1

CHANNEL 2: CAL 2, SCALE= 1X, OFFSET=1

RESOLUTION ELEMENTS 370-390, SCAN LINES 03544-03711

« ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 14:08:05 SEP 27, 1972 »

OTRACE, VERSION 2.0, P.F. LAMBECH

1/4 INCH SPACING, 1 INCH MAX AMPLITUDE, 1 LINE X 1 ELEMENT AVERAGING
PLOT ELEMENTS 370-390, ALL LINES

CONSECUTIVE ELEMENTS TRACED ACROSS TAR PAPER STRIPS, ETC.

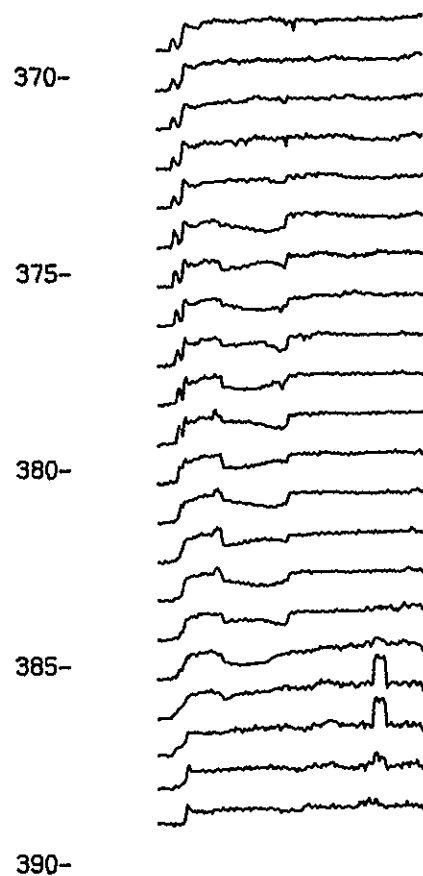


Figure 10.6

11
Cloud Shadows

Figure 11.1 is a print made from an RC-8 photograph taken from 1.5 thousand feet showing a cloud shadow which was present over a freshly planted field along the flight line north of the ramp during run 18 on 4 June. Figure 11.2 is an enlargement made from the inflight film recorder output for channel 8 during this run. Most of the horizontal streaks visible in this film are probably due to non-uniformities in the incremental movement of the film past the CRT which exposes it, while the lengthwise streaks are probably due to non-uniformities in the CRT phosphor or to non-uniformities in the staircase CRT sweep waveform.

Note the differences between Figures 11.1 and 11.2 in the location of various portions of the cloud shadow, indicating that the cloud was both moving and changing shape. Since the cloud was more or less following the path of the aircraft but at a slower speed, the outline of the cloud depicted in Figure 11.2 is elongated slightly in the flight direction relative to what appears in Figure 11.1. This indicates that the RC-8 film should not always be trusted to indicate the precise shape and location of a cloud shadow in the scanner data.

Figure 11.3 is a contour plot showing an approximate outline for this cloud shadow as indicated in channel 8 (compare with Figure 11.2). In this figure note the outline of a small tree and its shadow, close to one edge of the cloud shadow, near resolution element 340 in scan line 2040. Figure 11.1 indicates that the center of the aircraft shadow probably passed over this tree crown. Figure 11.4 plots the average of the 16 sample elements from the sky reference calibration signal for each scan line from line 2100 through 3050 in channel 8, while Figure 11.5 plots a single element (340) traced across scan lines (and over the crown of the small tree) for lines 1476-2157 in channel 8, approximating the path of the aircraft shadow over the ground. A low signal level representing the tree shadow followed by a high signal representing the sunlit crown of the small tree appears between scan lines 2028 and 2043 in Figure 11.5, followed by a dip in the signal representing the small blob of cloud shadow next to this tree. In Figure 11.4 the sky reference shows a similar signal dip between scan lines 2230 and 2290, indicating that the aircraft actually flew through this portion of the cloud shadow about 200 scan lines after it had scanned over it on the ground. This would correspond (from geometrical calculations) to the sun being approximately 22° away from zenith, ahead of the aircraft at 17:43 GMT (12:43 EST), which is about right. This indicates the lack of correlation one would expect between the sky reference signal and the location of small, sharply defined cloud shadows.

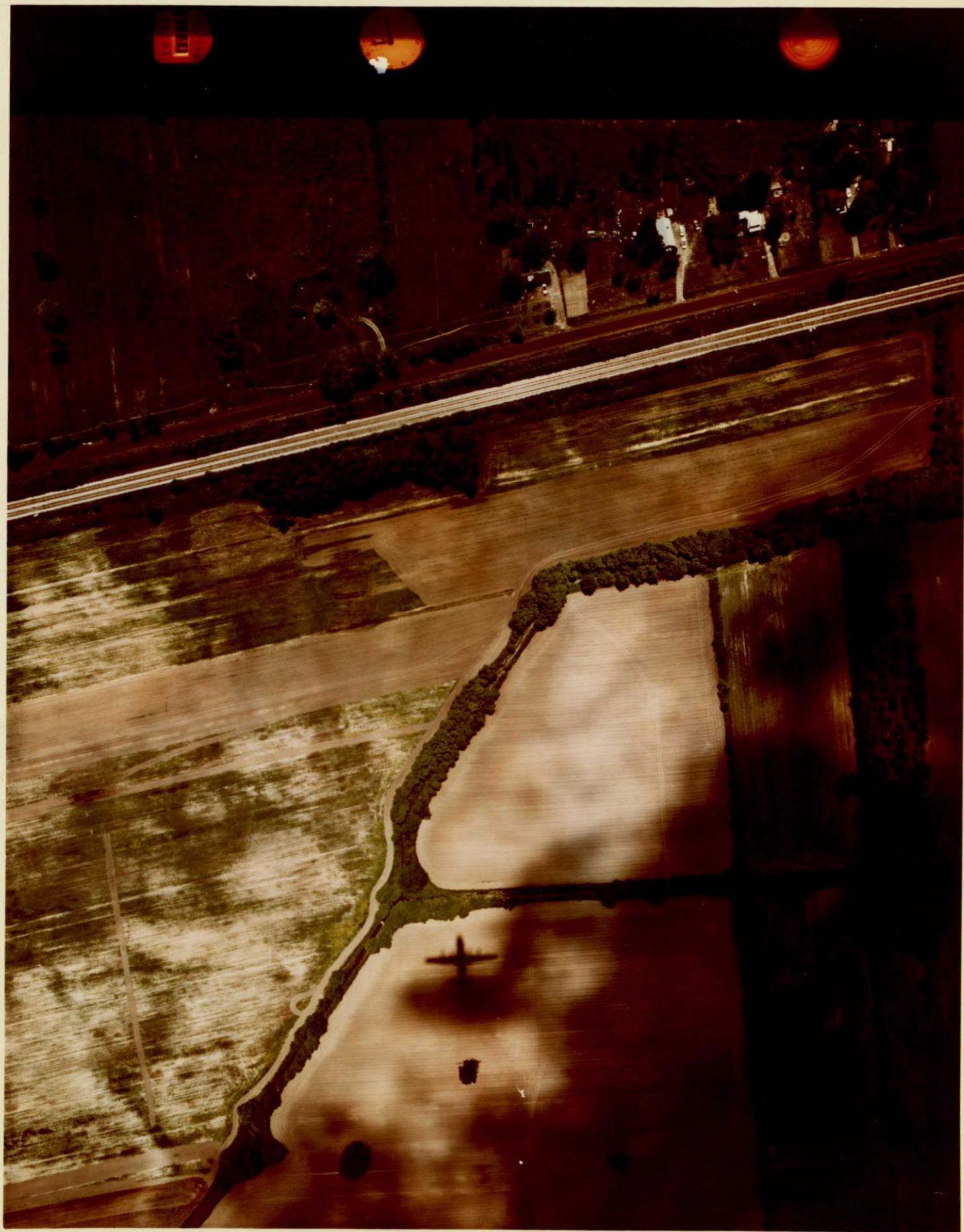


Figure 11.1
Cloud shadow
1.5K ft. 6/4/72



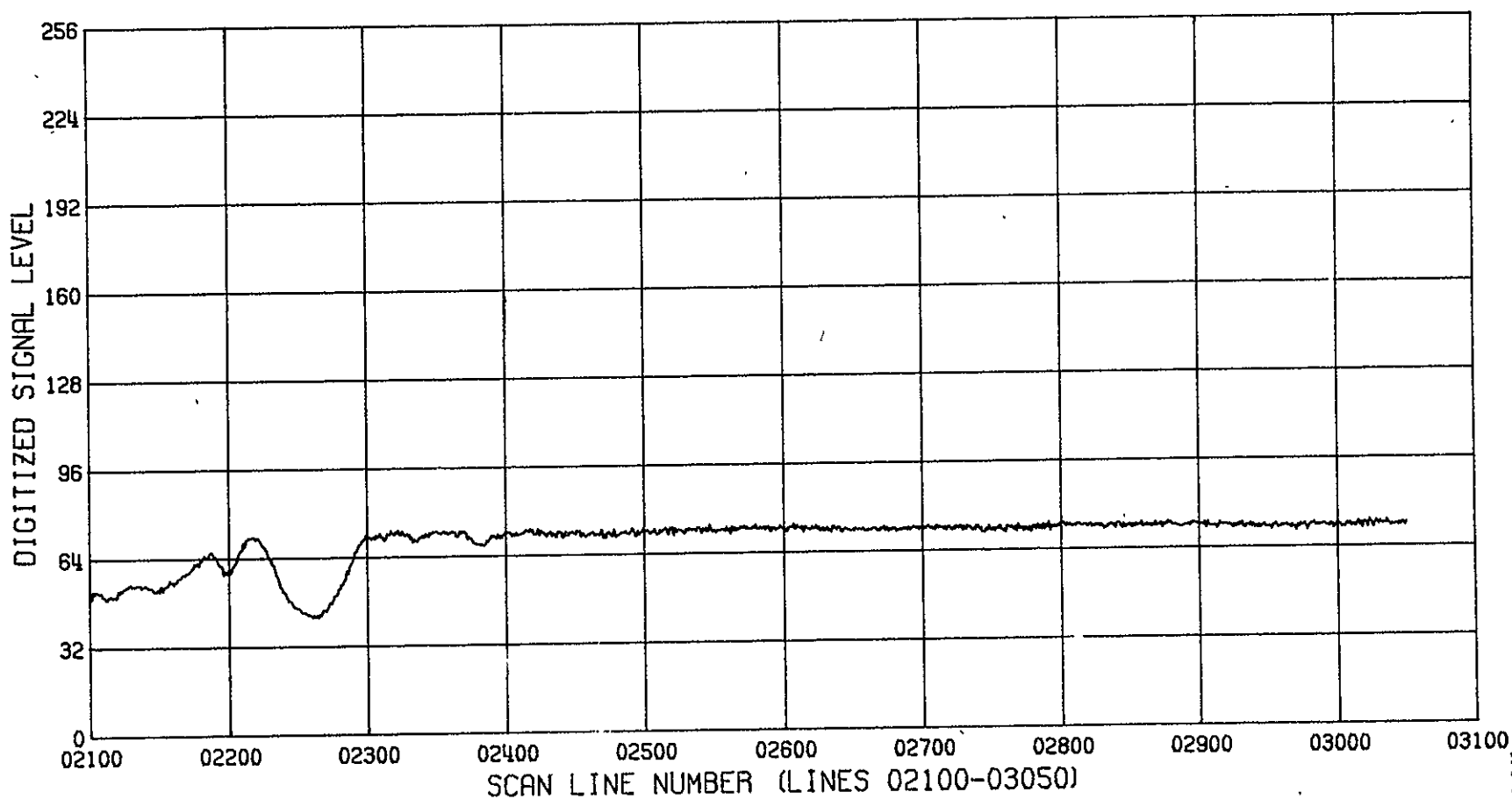
Figure 11.2
Inflight Film, Ch.8
1.5K ft. 6/4/72

HSS158-72-E, F3 L2 R10 (CLEAR) 1.5K, CLOUD SHADOW - PART 2 (08/15/72)
V/M=0.179 LOW TEMP=-11.2°C $\Delta T=36.0^\circ\text{C}$ FILTER SELECT=1 3.557 $\mu\text{SEC/ELEMENT}$
SEGMENT 1 OF 1
CHANNEL 0: CAL 2, SCALE=1X, OFFSET=1

" ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 21:38:04 NOV 1, 1972 "
(SHALLPLOT, VERSION 2.0, P.F. LANBECO)
AVERAGE CAL SOURCE 3, SAMPLES 1-16, LINES 2100-3050

Figure 11.4

AVERAGED SKY REFERENCE SIGNAL NEAR CLOUD SHADOW



N99156-72-E, F3 L2 R10 (CLERR) 1.5K, CLOUD SHADOW - PART 1 (06/15/72)
 06/04/72 17:42:54.1, RADAR ALT 01940 FT, TRUE HEADING 176.4°, DRIFT +02.5°
 V/T=0.179 LOW TEMP=-11.2°C ΔT=36.6°C FILTER SELECT=1 3.557/SEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 8: CRL 2, SCALE= 1X, OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 15:16:59 SEP 8, 1972 *
 (CONTOUR, VERSION 2.0, P.F. LARSEN)
 CONTOUR AT LEVEL 66 - 1 LINE X 1 ELEMENT AVERAGING
 PLOT LINES 1800-2157, ALL ELEMENTS

OUTLINE OF CLOUD SHADOW

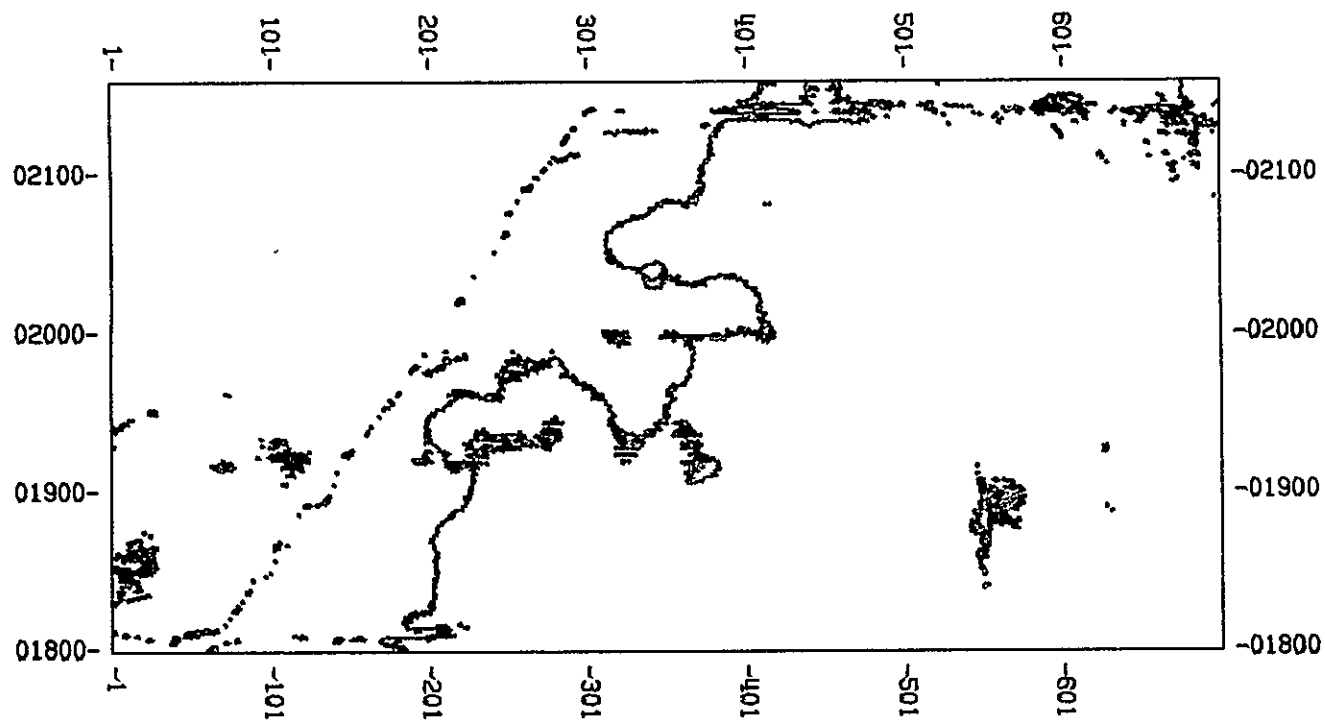
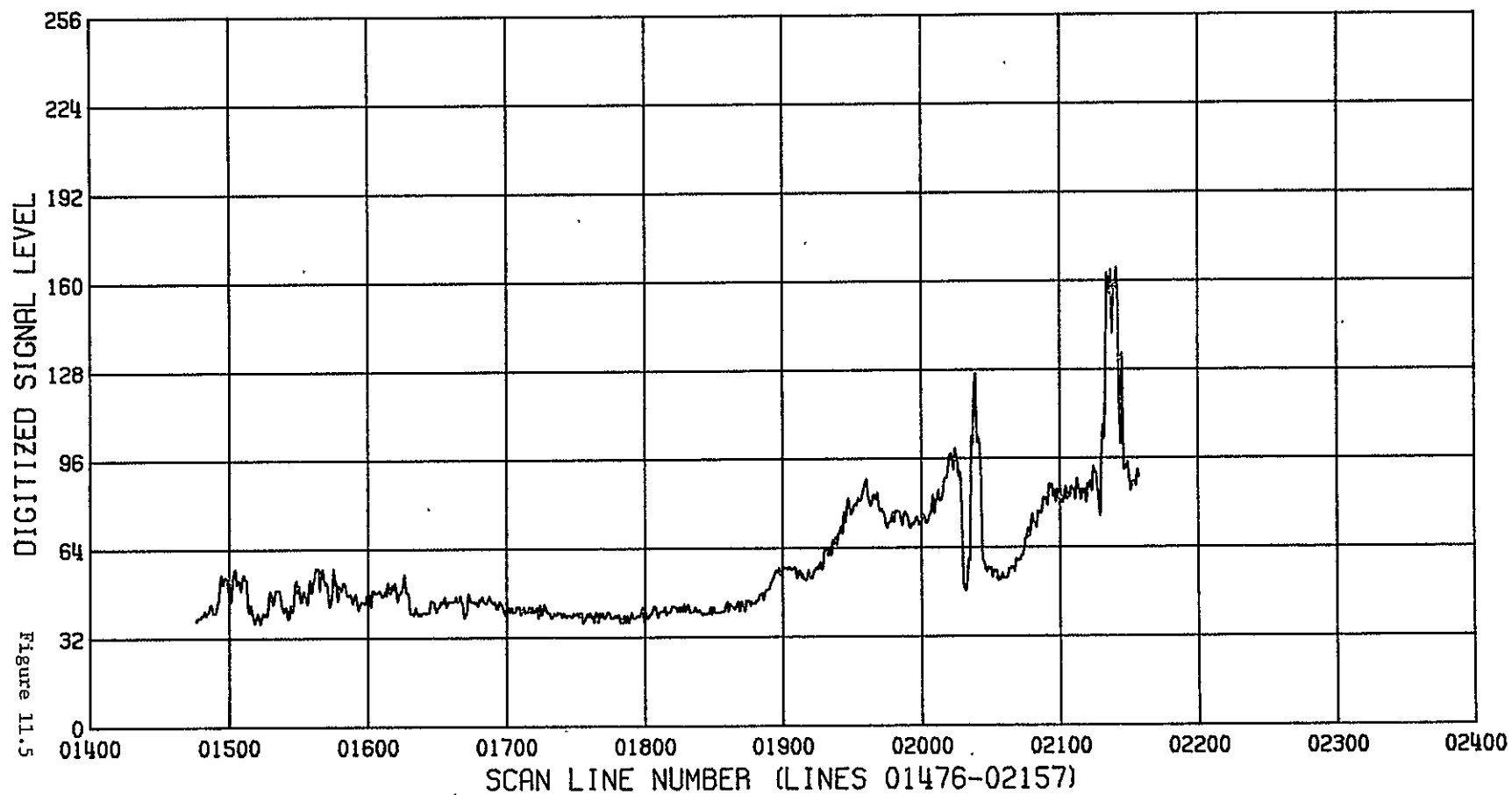


Figure 11.3

MSS166-72-E, F3 L2 R18 CLEAR 1.5K. CLOUD SHADOW - PART 1 (06/15/72)
 06/04/72 17:42:54.1. RADAR ALT 01340 FT. TRUE HEADING 178.4°. DRIFT +02.3°
 V/H=0.178 LOW TEMP=-11.2°C ΔT=36.6°C FILTER_SELECT=1 3.657μSEC/ELEMENT
 SEGMENT 1 OF 1
 CHANNEL 0: CH1 2. SCALE= 1X . OFFSET=1

* ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN 22:24:10 AUG 21, 1972 *
 SMALLPLOT, VERSION 2.0, P.F. LAMBECKO
 PLOT ELEMENT 340, ALL LINES

SINGLE ELEMENT TRACED ACROSS CLOUD SHADOW



12
Sun Glint

Figure 12.1 is a print made from an RC-8 photograph taken over Belleville Lake during run 12 (1.7 thousand feet) on 4 June. Figure 12.2 is an enlargement of output from the inflight film recorder for this same portion of run 12 for channel 3. Note that sun glint forms a different pattern in the scanner data from that shown in the RC-8 photograph.

Again horizontal and vertical streaks are visible in the film recorder printout as mentioned in Section 11. Close inspection of this film indicates that individual resolution elements can perhaps be identified occasionally, although there appears to be emphasis in brightness upon alternate resolution elements as if the CRT sweep waveform preferred "even" voltage levels over "odd" ones, or vice versa. There is an even more prominent emphasis on every 4th resolution element, giving rise to the vertical white streaks which appear in the enlargement, spaced a little less than 1mm apart.

Note the lack of evidence for clipping or ringing in this film recorder output for channel 3. Earlier in this same run clipping and ringing were noted in the digitized data for this channel (see Section 6 and Figure 6.21). This indicates that the abnormalities in channel 3 occur downstream from the connection for input to the film recorder in this channel.



Figure 12.1
1.7K ft. over lake
6/4/72 (clear)

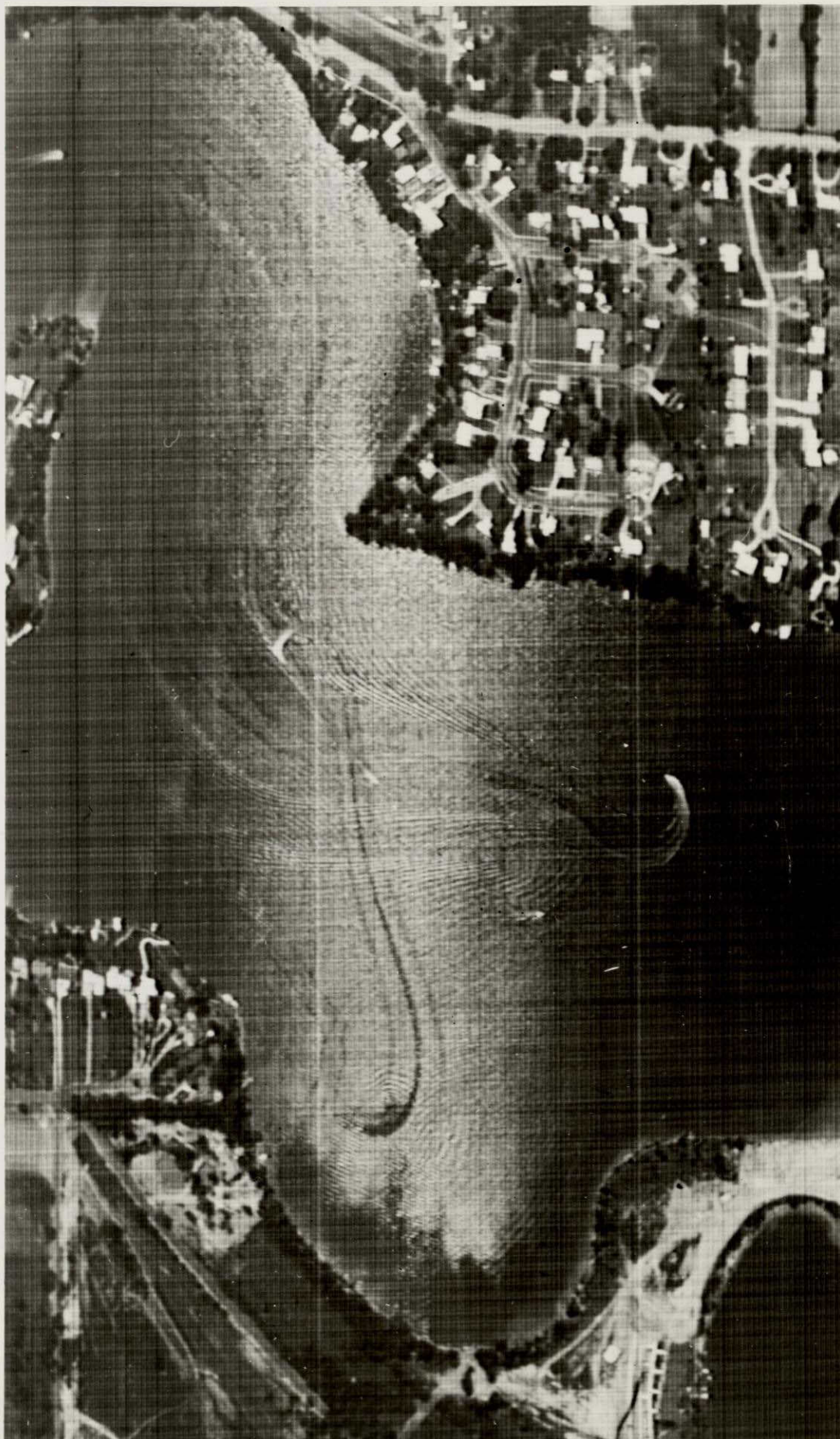


Figure 12.2
Inflight Film, Ch. 3
1.7K ft. 6/4/72

13
DAS Film Edits

Figures 13.1-13.6 are examples of some of the better DAS film edits we obtained for the 2 June and 4 June flights, representing various altitudes and V/H's. In general this film was distorted (compressed in scale by a factor of 5, more or less, throughout the first 100 elements or so of each scan line) and faded out with a sometimes ragged edge toward the end of each scan line. In a few instances film edits contained wavy distortions which thoroughly obscured the smaller features of the scene. In the figures presented note that there are some horizontal and vertical streaks similar to those in the inflight film printout, but a bit more subtle. The DAS film gives the impression of being a bit out of focus relative to the inflight film enlargements (see Figure 12.2), however features the size of one resolution element can be identified.

For Figures 13.1-13.5 channel 19 was used for the red gun, channel 2 for the green, and channel 11 for blue. In Figure 13.4 note that the seven tar paper strips can be seen separately (whenever the moiré pattern present does not obscure them) even though the resolution element size in that figure is nearly identical to the width of these strips (3 feet). In Figure 13.5, edit 44, note that these strips cannot be seen separately even though they do appear separated in the graymap from the corresponding tape edit shown in Figure 10.4. This apparent lack of resolution appears partly due to the presence of vertical streaks in the DAS film, partly due to the reduced signal contrast over these strips resulting from the reduced scanner response along the scan relative to across the scan lines together with the effect of the overcast conditions for that day, and partly due to the lack of signal registration among the three channels, chosen for this edit at its V/H of .16 which leads to a different moiré pattern effect in each channel.

Figure 13.6 is a crude attempt at producing a natural color DAS film print using channel 6 for red, channel 4 for green, and channel 2 for blue. The colors of the original DAS film edit were slightly more natural than what is indicated by this print. The distortion appearing in the upper half of the print comes from a deliberate 5° roll of the aircraft during this run to test the roll compensation of the scanner (which was not compensating properly during these flights).

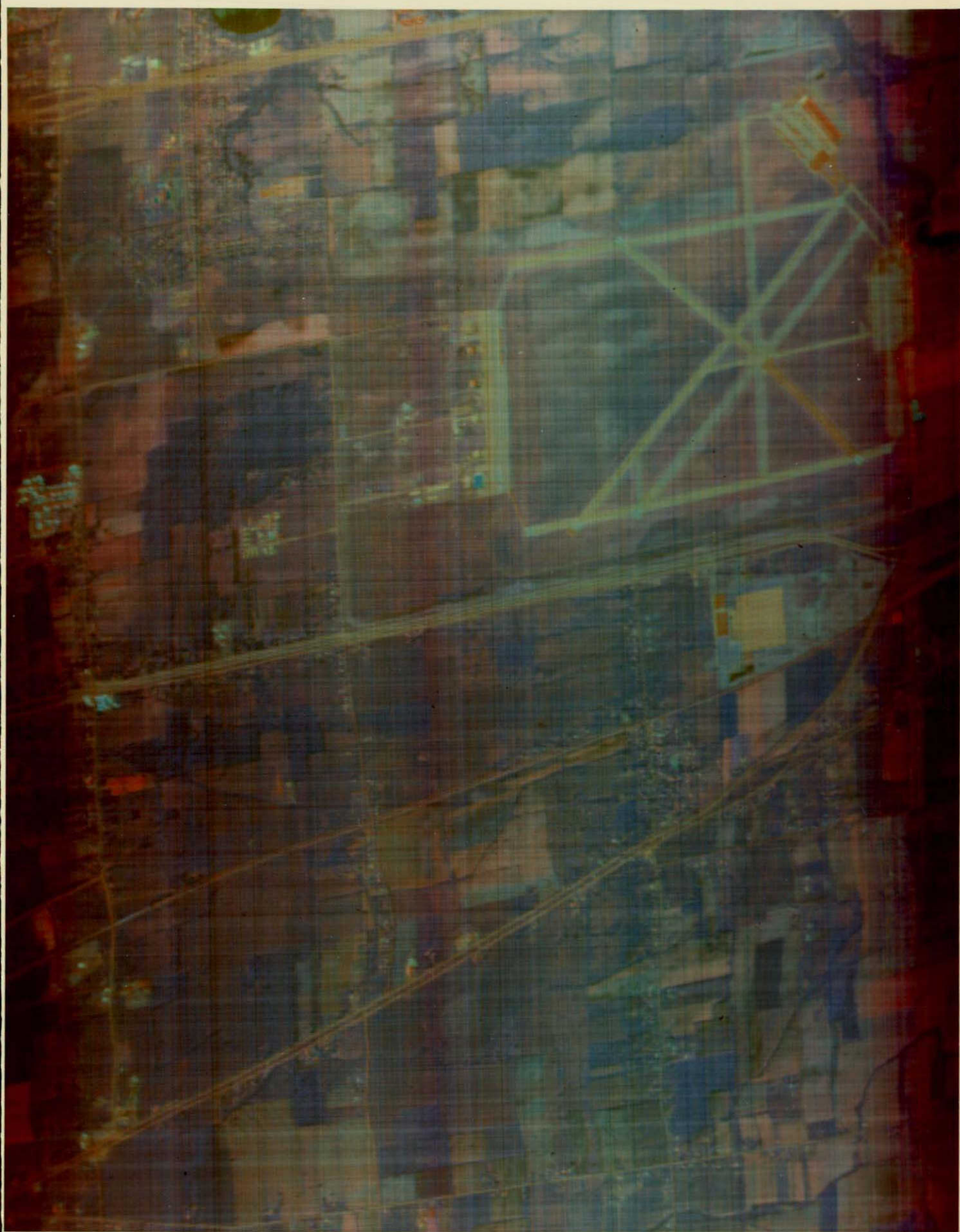


Figure 13.1
DAS Film, Run 2
14.7K ft. 6/4/72
19-R 2-G 11-B

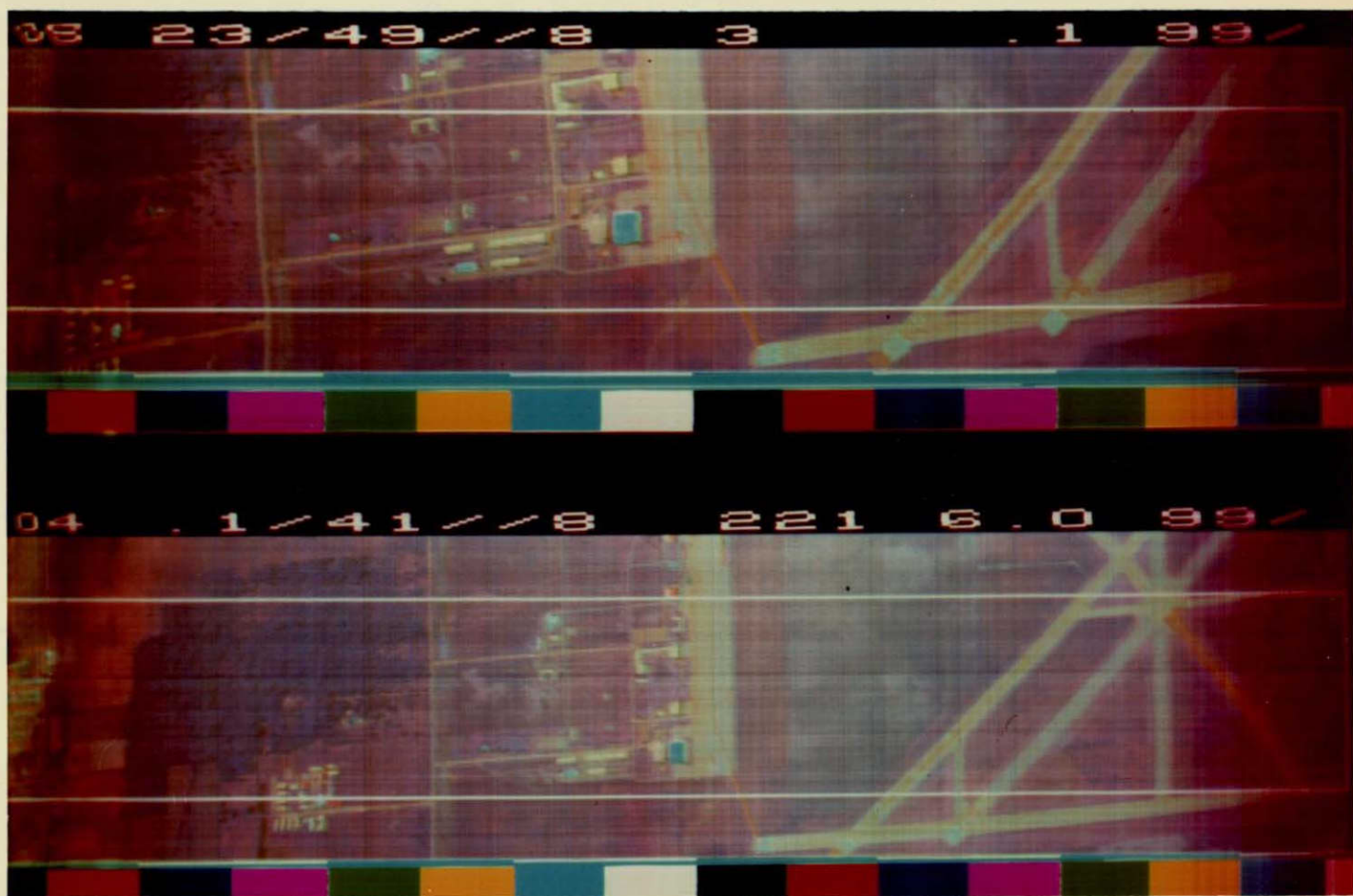


Figure 13.2
DAS Film, Runs 4 & 5
10 & 6.7K ft. 6/4/72
19-R 2-G 11-B

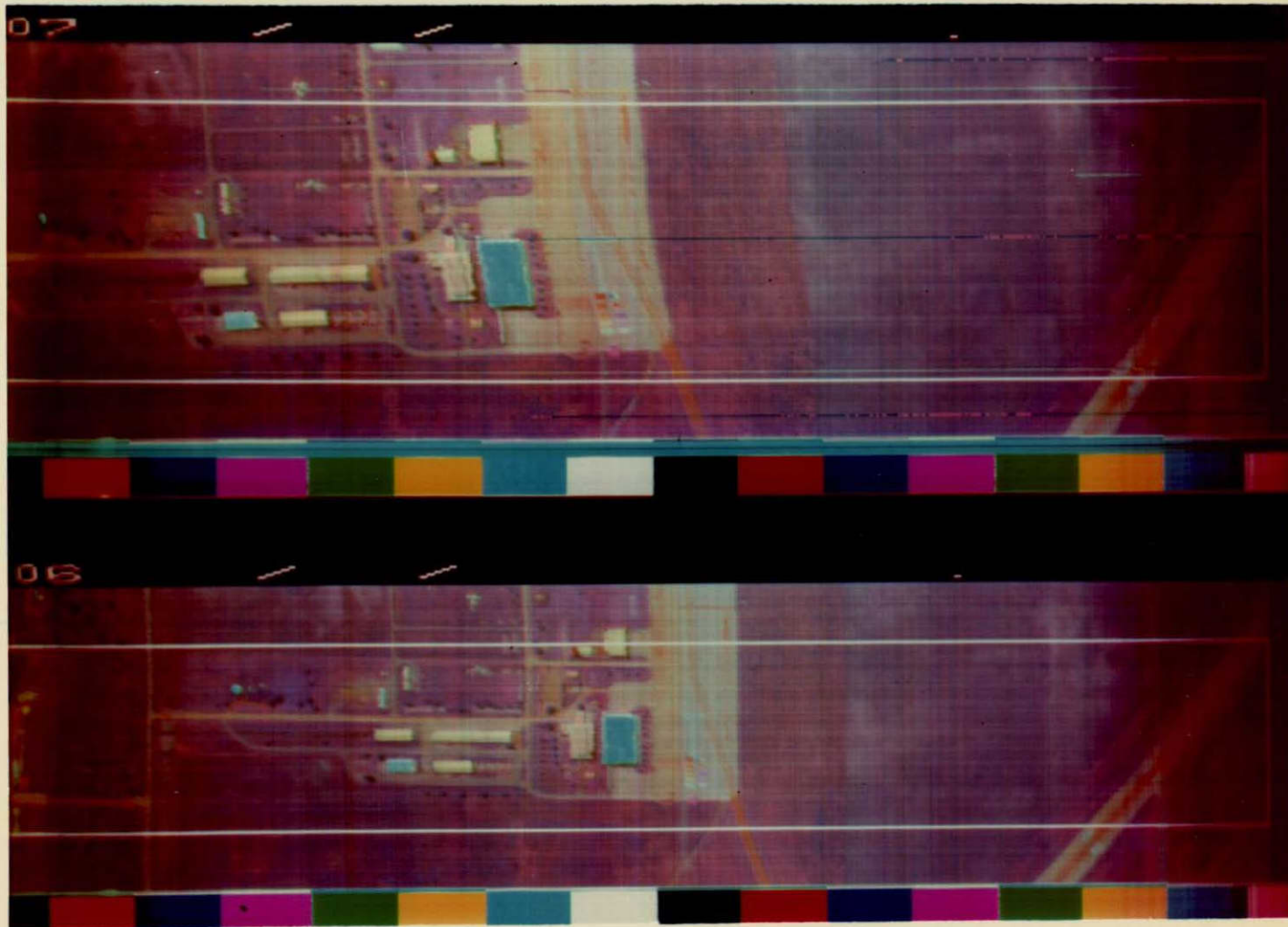


Figure 13.3
DAS Film, Runs 6 & 7
4.5 & 3.4K ft. 6/4/72
19-R 2-G 11-B

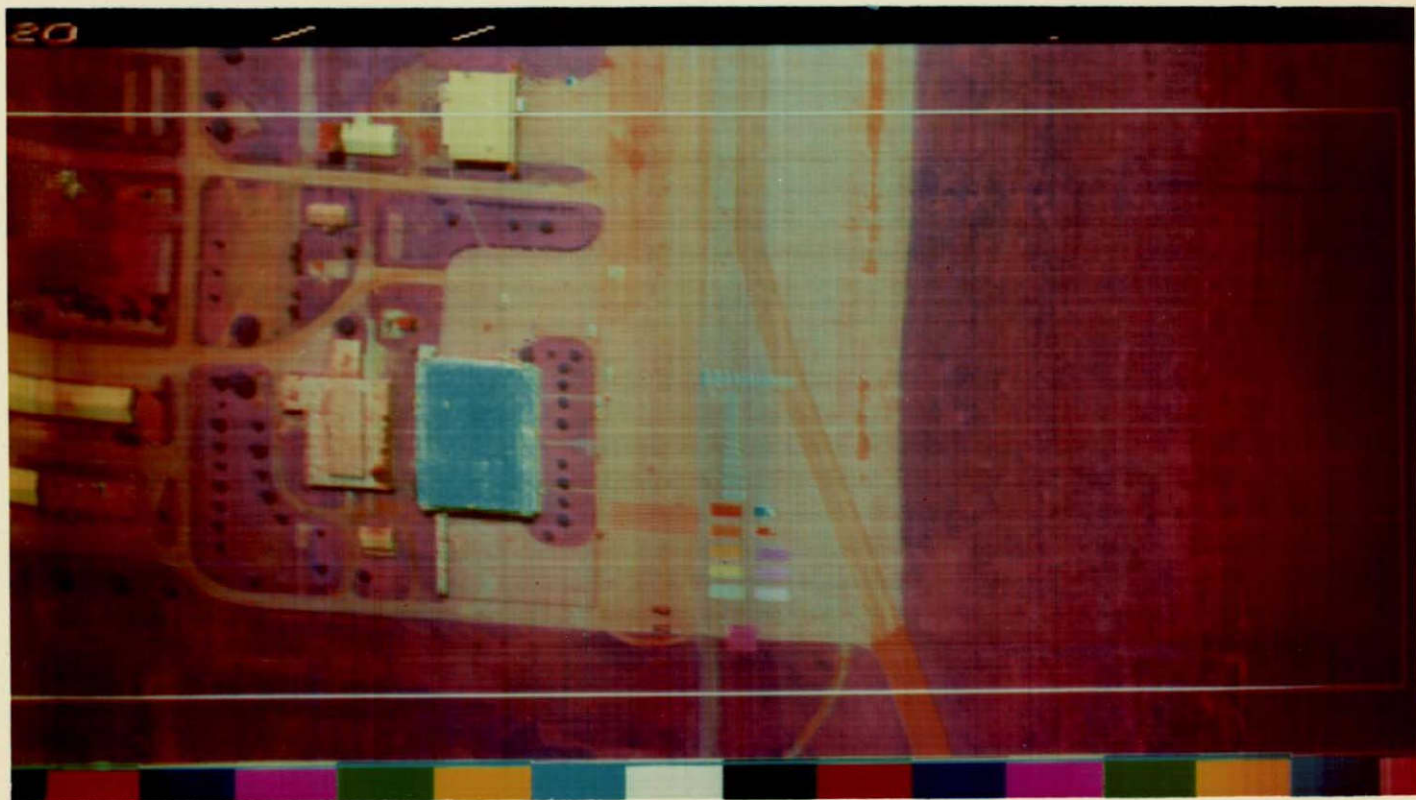


Figure 13.4
DAS Film, Run 18
1.5K ft. 6/4/72
19-R 2-G 11-B

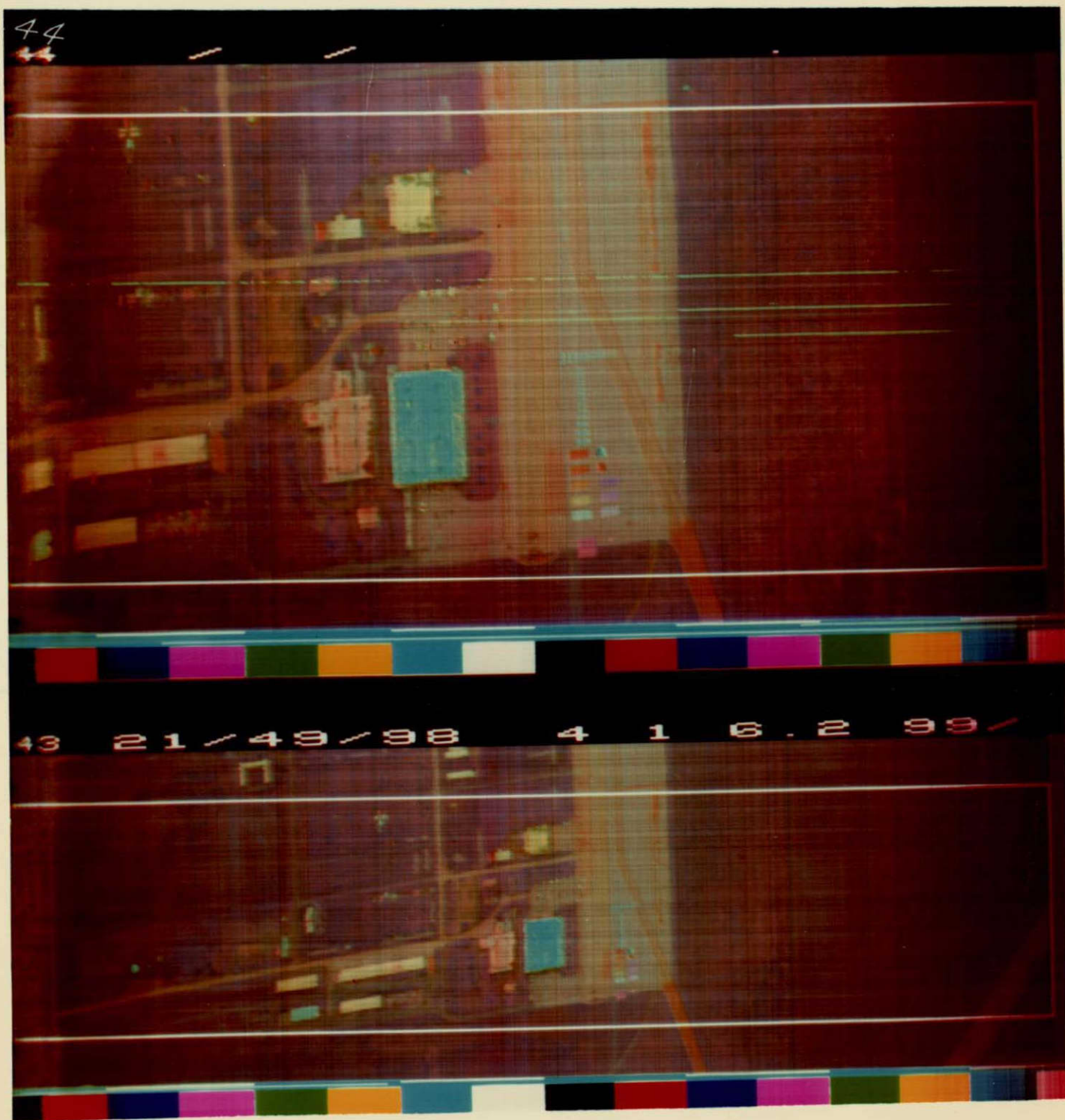


Figure 13.5
DAS Film, Runs 7 & 12
3.4 & 1.7K ft. 6/2/72
19-R 2-G 11-B

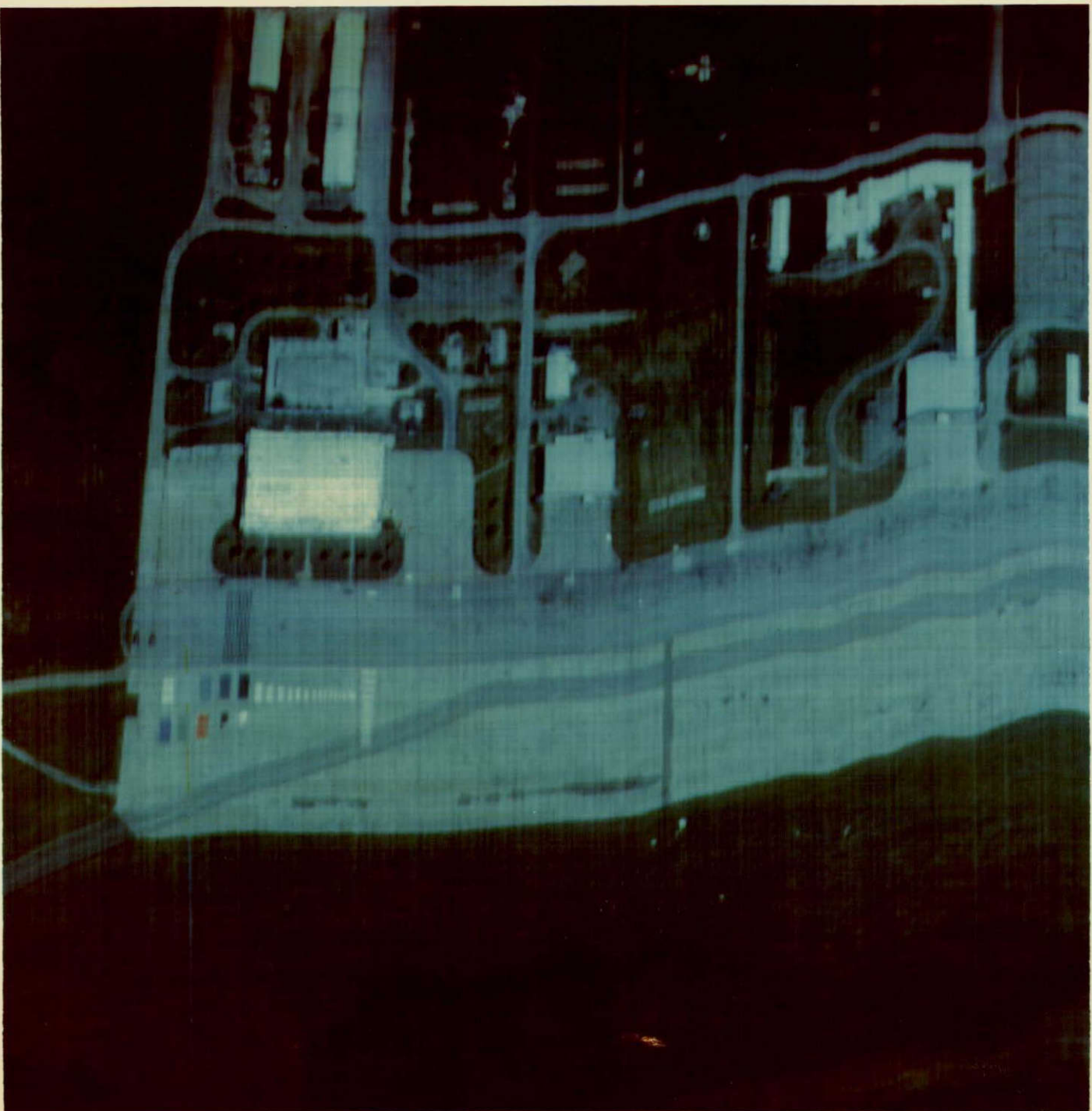


Figure 13.6
DAS Film, Run 20
1.7K ft.
6/4/72
4-G
2-B
6-R

Tape Edit Housekeeping Data and Roll Compensation

The tape edit housekeeping data was subject to a few problems, some of which were persistent while others were intermittent. Throughout the 2 June and 4 June flights as well as during the PVT's performed prior to the flight in May at Ellington Air Force Base and at Hobby Airport, the 8 bit of the last digit of the V/H value recorded in the housekeeping was stuck on 1, causing this digit to be in error most of the time and to be completely invalid occasionally. In the documentation with the plots presented in this report, questionable V/H values translated from the housekeeping data are followed by a question mark. The number of micro-seconds per resolution element listed in the plot documentation is based on a correction for these questioned V/H's, performed during an interruption of the plotting program by resetting the 8 bit of the last V/H digit to a zero.

The scan line count kept resetting to zero every time the gyro was caged during the 2 June and 4 June flights, causing non-unique scan line numbering for each run. This resulted in one of our tape edits (run 2, 2 June) being mistakenly taken from the wrong run (run 3) using the same scan line numbers.

The scan line number quoted in the start ID housekeeping record appears to be consistently 1 less than the line number of the first scan line of a tape edit (as indicated in the first calibration source location), while the scan line number quoted in the stop ID housekeeping record appears to be consistently 1 greater than the line number of the last scan line of a tape edit (as indicated in the first calibration source location).

Two tape edits were received having stop ID scan line numbers which failed to correspond to the start ID scan line numbers and the number of scan lines in the edit. In both of these cases the V/H indicated in the start ID record was .169(?) while it was .188(?) in the stop ID records. These two edits were EAFB PVT A/D test, 12 May, scan lines 28271-28470 (according to start ID), stop ID scan number 28872; and Hobby PVT transfer calibration for bulb #6, 25 May, scan lines 10221-10420 (according to start ID), stop ID scan number 10392.

Some additional anomalies were observed in the housekeeping data. In the tape edit we received for the Hobby PVT transfer calibration for bulb #2, 25 May, both the start ID and stop ID records were mostly written over (obliterated) with alternating 0's and 1's. In two of the Hobby PVT knife edge tape edits we received (25 May, V/H = .02 and V/H = .1) the scan status word had a 4 bit stuck on zero. Some additional comments on disruptions in the housekeeping data involving the temperature monitors have been included in Section 7. There is a remote but unlikely possibility that the excessive clipping observed in the temperature monitor data for arrays 2 and 4 and for the lamp current as well could be due to multiple bit hang-ups.

The ASQ-90 data was present only 1/3 of the time in tape edit ID records for the 2 June and 4 June flights with V/H greater than .08, while it was present all the time for V/H's less than .08.

Inspection of the RC-8 film we received indicates that roll compensation for the RC-8 cameras was working, while pitch correction may have had excessive drift. Improper roll and pitch compensation for these cameras will cause distortions of geometry in the photographs obtained. Some additional distortions of geometry have been introduced in the prints from RC-8 film included in this report together with some noticeable color differences. The original RC-8 film transparencies we received are truly beautiful (especially the color film).

Roll compensation was not working properly for the scanner data, as indicated in Figure 14.1, an enlargement from the inflight film recorder output for channel 13 (a noisy channel with motor spikes) during run 20 on 4 June. During this portion of the run the aircraft was deliberately rolled 5° right, then 5° left to test the system for roll compensation.

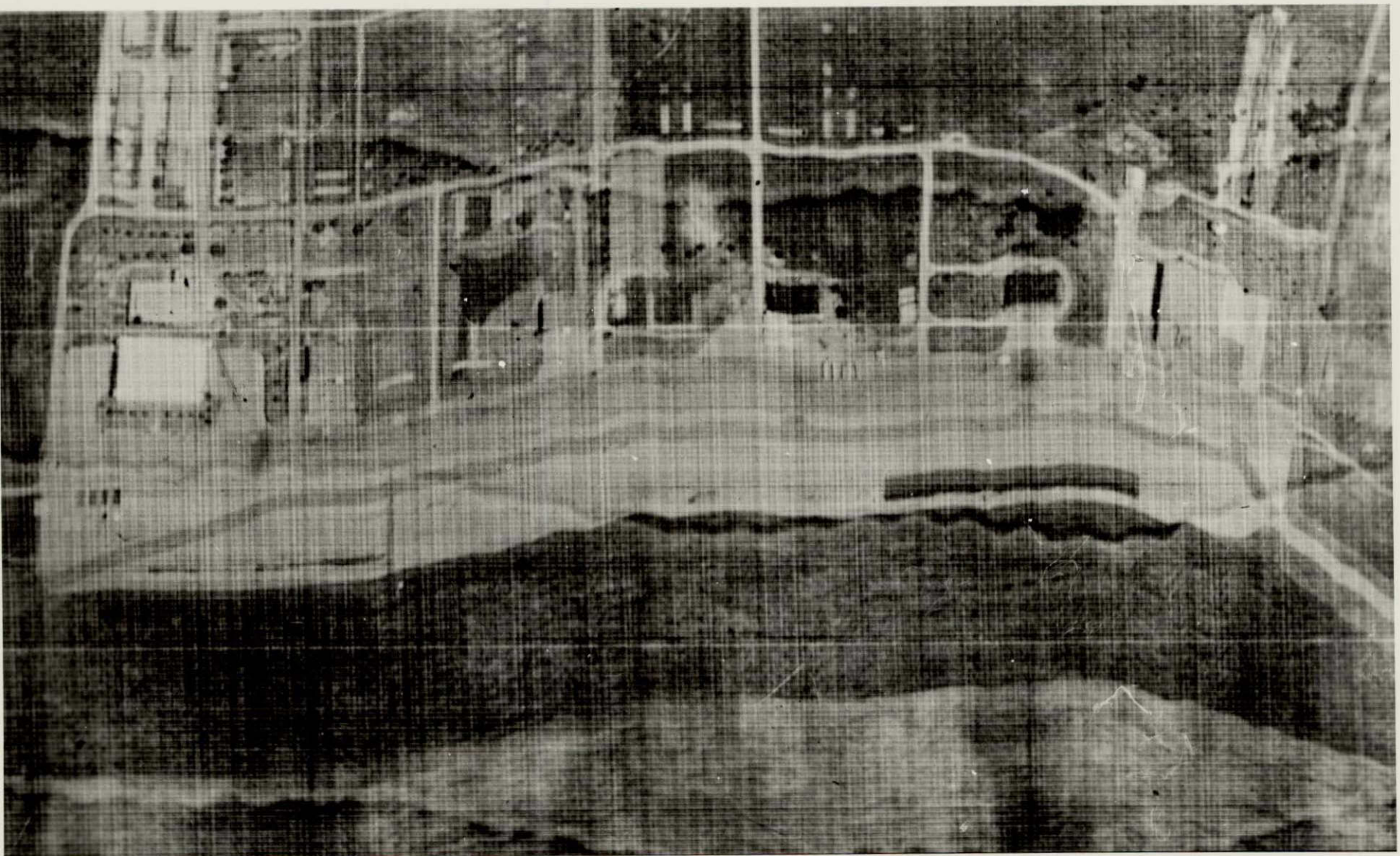


Figure 14.1
Inflight Film, Ch. 13
1.7K ft. 6/4/72

Data Acquisition After Flight

It appears that one should not expect to receive inflight film recorder output, RC-8 film, DAS film edits or PRT-5 plots and tabulations any sooner than one or two months after a flight has taken place, and even then this same delay should be expected relative to the date on which such data is requested. This is regrettable since some form of aerial imagery with a field of view approximating that of the scanner is of great use during the selection of tape edits - a slow and tedious process which is in need of any help it can get to speed it up. Tape edits can be selected as soon as one week after a flight, if only one can succeed in locating the data he wants to have edited from the flight tape. This data has to be located through an approximate knowledge of the GMT time or scan line numbers at which the data was collected, together with a succession of slow playbacks of portions of the flight data on the television monitor. These playbacks can be correlated with the location along the flight line only if details of the scene along the flight line and adjacent to the area of interest are known. For this purpose quick availability of the inflight film recorder output (or, alternatively, RC-8 film) would be desirable.

The DAS film editing procedure is an even slower process which discourages one from requesting more than a bare minimum of such imagery.

Snapshots which we took of the television monitor during the selection of our tape edits, although they slowed down the editing process slightly, were found to be useful in locating data of interest within a large edit to a first order approximation (plus or minus 5 resolution elements). If enough users wish to obtain large tape edits (one half screen of data or more), it would be worthwhile to have a polaroid camera permanently ready for their use in taking such photographs. These photographs also reproduce scan line numbers from the television monitor which do not appear on the DAS film edits.

16
General Flight Performance

The design of the MSDS system inside the aircraft to some extent invites errors on the part of the operators. In particular the two separate sets of controls for ΔT , one set to actually change ΔT and the other set just to arrange for ΔT to be recorded properly in the house-keeping data on the flight tape, invites the operator to perform adjustments in ΔT as requested but to neglect to adjust the housekeeping controls to allow the value to be recorded properly, as was found to happen during run 14 on 4 June. The scale and offset selector switches for each of the channels are small and are difficult to read and to operate, consequently throughout the 2 June edits we received channel 3 appears set at a scale of 2X (rather than 1X), while channel 6 appears set at 2X scale (rather than 1X) for runs through run 7, and channel 2 appears set at .25X (rather than 1X) for the A/D and I/H tests which preceded the other runs on that day.

Many of the knife edge tests run at Hobby Airport, 25 May, were run with the knife edge reversed from the orientation that was requested, as noted in Section 2.

The inflight film recorder output was washed out for the first 100 or 200 scan lines of each run. Perhaps this can be avoided, as has been suggested in the past, by putting a 2 inch blank space on the film between runs.

Some problems were encountered with the scan motor overheating and cutting out after repeated runs at the higher V/H's. This problem could cause substantial difficulties in completing a flight requiring many such runs according to schedule (e.g., partially overlapping parallel flight lines clustered about an optimum time of day to survey a large contiguous area on the ground).

No radio frequency interference was noted on any channel of the scanner during run 22 (4 June) for the UHF and VHF communication equipment, the DME, the RADAR, or the transponder.